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GEOLOGICAL AND MINING

REPORT

ON THE

LEINSTER COAL DISTRICT.

BY RICHARD GRIFFITH, JUN. ESQ.

INSPECTOR GENERAL OF HIS MAJESTY'S ROYAL MINES IN
IRELAND, MINING ENGINEER TO THE DUBLIN SOCIETY,
F. R. S. EDINBURGH, &c. &c. &c.

DUBLIN:
Graisberry and Campbell,
PRINTERS TO THE DUBLIN SOCIETY.

1814.

TO THE

RIGHT HONOURABLE AND HONOURABLE

THE DUBLIN SOCIETY.

MY LORDS AND GENTLEMEN,

HEREWITH I have the honor of laying before you my Geological and Mining Report on the Leinster Coal District, accompanied by a Map and several Sections. I have also added Accounts and Plans of the most improved Methods of working Coal, as practised in England.

I hope the whole may prove acceptable to you, and beneficial to Coal Mining in Ireland.

I have the honor to be,
My Lords and Gentlemen,
Your most obedient humble servant,
RICHARD GRIFFITH, JUN.
MINING ENGINEER.

Dublin Society House,
May 11th, 1814.

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INTRODUCTION.

THE Mines of Ireland have hitherto been conducted on so rude and unscientific a system, that the ruin of those engaged in them has been almost invariable; and owing to the dread of mining speculations, which these failures have occasioned, the internal treasures of Ireland remain unexplored, although there is scarcely a county in the Island, which does not exhibit indications of valuable mineral productions.

Various plans have at different times been suggested, to remove a dread so injurious to the prosperity of the country, by introducing a regular arrangement in the working of mines, founded on scientific principles.

Our celebrated countryman, the late Mr. Kirwan, laid a proposal before Government for a mining board, similar to those, under whose guidance the German mines are conducted; but it was imagined, that the control, which this Board was intended to possess over all the mines in the country, would interfere too much with the property of private individuals, and could not be carried into effect, consistently with the freedom of the British Constitution.

The late Right Honourable Charles Greville, the enlightened patron of mineralogical science, was also very anxious on this subject; and, a very short time previous to his lamented death, he addressed a letter to the Earl of Liverpool, pointing out the benefit, which Ireland would derive from a general examination of its mines and minerals.

It was, however, reserved for the Dublin Society to make the first efforts toward improvement, by setting on foot accurate and minute mineralogical surveys of the several mining districts of Ireland.

Their first attention has been directed to the coal mines of this country, and the mineralogical examination of the Kilkenny, or Leinster coal district, which is one of the most important; forms the subject of the following Report.

When it is considered what vast sums of money have in almost every part of Ireland been expended, in searching for coal, where none was likely to be discovered, few will doubt of the benefit, which the country must derive from an accurate examination of each particular district, that exhibits indications of that valuable substance. Nearly the whole of the failures which have occurred, and certainly all those where fruitless searches have been made, have originated in the fraud, or ignorance of the agents employed. Many common English collier's have at different times been invited over to Ireland, to explore the country in search of coal; and, as few places could be selected, which do not exhibit some trifling appearances similar to those of a coal country, (any one of which is sufficient for a common collier to recommend the commencement of workings,) we need not be surprised at the number of trials, and consequent failures which have occurred. The most common of these supposed indications are chalybeate springs, which occur every where. They are met with very frequently throughout the whole of the great limestone district of Ireland, which contains no coal, as well as in the coal countries. Chalybeate springs can therefore be no indication of coal.

Slate-clay either black, grey, or reddish grey, is another supposed indication of coal, and is certainly common in all coal countries, but not peculiar to them. This rock is frequently found alternating with limestone, and particularly that species called *calp*, which occurs in the neighbourhood of Dublin.

This slate-clay contains balls of clay ironstone, another supposed indication; and, as chalybeate springs are also met with in great number, the calp country contains three supposed indications of coal. These appearances have been deemed quite conclusive in the eyes of many professed miners; and at their recommendation trials were made in many places to the North and West of the city of Dublin, particularly at Castletown, and near Lucan; and within this year by a gentleman close to the new Spa well, at Golden Bridge. *

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* At the request of the proprietor I visited this quarry, and having examined it, was decidedly of opinion, that there was no probability of finding coal there.

Trials have also been made in various parts of the county of Meath, and some pits have been sunk in search of coal, in a transition clay-slate country, near Newtown-ards in the county of Down, and in other places, merely because the slate was coloured black, arising from the decomposition of some iron pyrites contained in it. In the trials near Newtown-ards, I have been credibly informed, that the colliers went so far as to say they found coal, and certainly raised some from the bottom of the pit, but it was as certainly taken down in the pockets of the colliers. This deceit has been practised more than once. It is unnecessary to enumerate here all the artifices that have been used, or the fruitless trials that have been made in search of coal in different parts of the country. It may be more useful to describe the different rocks, which are usually found accompanying coal. They consist of alternations of *sandstone*, *slaty micaceous sandstone*, or *sandstone slate*, *slate-clay*, *clay ironstone*, and *fire-clay*. Other rocks are however met with occasionally, as lime-stone, porphyritic stone, and greenstone.

The sandstone of the coal formation is composed of particles of siliceous sand of various degrees of fineness, cemented together by a calcareous, or argillaceous paste. It frequently contains impressions of large reeds, and stems of trees, but they are merely impressions or casts on the sandstone rock; for no vegetable matter remains. Sometimes however, impressions of the branches of large trees have been discovered, and then a coating of coal is frequently found, surrounding the impression, and occupying the place of the bark. Coal sandstones are frequently micaceous; they sometimes divide into thin beds, and are used as flags. The Carlow flags are of this species. The hardness and compactness of sandstone differ very much in different coal districts. The sandstone of most of the coal fields of England, and Scotland, is found to be a cheap, durable, and ornamental building stone. The sandstone of the Leinster coal district is so extremely hard, and untractable under the hammer and chissel, that no use is made of it, except in the roughest buildings. This is to be regretted, as sandstone is superior to limestone for building, in as much as it does not attract moisture in the same proportion, The usual colour of sandstone of the coal formation is yellowish grey, which passes into white; it is sometimes smoke-grey, and rarely dark brown or red. The sandstone of the English collieries is generally yellowish grey; with us it is smoke-grey. Red sandstone occurs in the collieries of the county of Tyrone. At the Kilkenny collieries, sandstone is called rock, as grey rock, &c. to distinguish it from slate clay, which is there called slate. At Newcastle upon Tyne, it is called post, as white post, grey post, &c. and in Scotland freestone, or stone, simply.

Slaty micaceous sandstone, is a rock intermediate between sandstone and slate clay, and partakes of the characters of both. It is composed of particles of sand, cemented by an argillaceous paste, which predominates. It frequently presents a stratified appearance, from its being divided into laminæ, some of which contain more sandy particles than the other, and are of a different colour.

Slate-clay is usually the most abundant rock of the coal formation. It is a dull earthy mineral, which easily divides into thin laminæ or flakes. It decomposes rapidly, when exposed to the atmosphere. Its colour varies from black to bluish black; sometimes it is grey, and rarely reddish. This rock often passes through the several gradations of slaty sandstone into sandstone, that is, the same bed is found in one part to be composed of slate-clay, and in another of slaty sandstone, and in a third of sandstone.

Slate-clay is sometimes so compact that it resembles jasper. In the Kilkenny coal district, instances frequently occur of its passing, by insensible gradations, from soft slate-clay into a siliceous slaty rock, resembling Lydian stone. This gradation is frequently visible in that district, near the junction of the limestone with the rocks of the coal formation. Slate clay frequently contains impressions of a great variety of vegetable substances, principally of ferns, and sometimes of aquatic plants. These impressions lie horizontally in the direction of the strata.

Mr. Jameson * says, that in the coal formation all petrifactions of small plants and reeds are found in this position; but that the larger arborescent plants often stand erect, with their stems filled with the substance of the superin-

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* Mineralogy, third volume.

cumbent strata, which seems to intimate, that these stems are in their original position.

Habel, in his "Natural History of Nassau," mentions, that he saw a petrified vegetable stem rise forty feet through rocks of the coal formation, and that the stem was one foot in diameter at one of its extremities.

Clay ironstone is generally found interstratified with slate clay, either in flattened spheroids detached from each other, or in beds, which frequently are only two or three inches in thickness, and rarely exceed six inches. This substance increases in weight, in proportion to the quantity of iron it contains. Its hardness is not great; it may easily be scratched by a knife. The fracture is conchoidal in every direction, and colour bluish black of various shades. Nearly the whole of our English iron is made from this substance, which sometimes contains 30 per cent. of iron, but rarely more than from 20, to 25 per cent.

Fire-clay is a substance, which has received no particular mineralogical name. Its colour is grey of various shades, but usually light smoke-grey. It is very soft, and its fracture is earthy. This substance generally contains vegetable impressions of rushes, reeds, and other aquatic plants. I have given it the name of *fire-clay*, from its being used, when decomposed by exposure to the air, and ground fine, to make bricks or crucibles, which will stand the intense heat of our glass-houses and other furnaces. It is usually met with in the coal series, immediately below the coal. On this account, it has received the name of coal sill, or seat, at the Kilkenny collieries. In England it is generally called *thill* by the colliers, which name is also given to slate-clay. Fire-clay is found in great quantity, and of very superior quality, at Stour-Bridge in Worcestershire, and from thence it is exported all over the British empire, and to India and America. The fire-clay met with below the different beds of coal in the Leinster coal district, is so similar in its appearance, and quality, to the fire-clay of Stour-Bridge, that I was induced to make trial of it in the intense heat of a glass-house furnace; which it stood so well, that it was judged by all who witnessed the experiment, to be equal, if not superior to the Stour-Bridge clay. It is to be hoped, that this natural advantage may not be much longer neglected, but that we may soon be able to supply ourselves, and even vie with our neighbours in the exportation of this very useful substance.

These five rocks, viz. sandstone, slaty sandstone, slate-clay, clay-ironstone, and fire-clay are met with in all coal districts. We shall now consider those rocks, which occasionally occur interstratified with them.

The limestone of the coal formation presents a dull earthy aspect. It is usually of a brownish or bluish grey colour, and frequently contains vegetable organic remains. Limestone of this species occurs in several coal fields in Scotland; particularly near Paisley, and in the neighbourhood of Edinburgh. It also occurs in the bituminous coal strata of the county of Antrim, and in other parts of the North of Ireland. Porphyritic stone and green-stone are of very rare occurrence in coal districts; neither of them have hitherto been discovered in Ireland, interstratified with rocks of the coal formation; but green-stone has been met with in some of the Scotch collieries.

Coal strata do not appear to have any determinate order; the rock which forms the roof, being as often sandstone as slate clay. It sometimes even happens, that the same bed of coal is covered in one part by sandstone, and in another by slate clay. In the Leinster coal district, (as I shall in future denominate the coal district of the counties of Kilkenny, Queen's county, and county of Carlow,) slate clay is usually found to be the roof of the coal, and fire-clay the substratum in every instance, but one. This remarkable exception will be dwelt upon in its proper place. In examining the rocky bed of a stream, or a precipitous cliff, in search of coal, the greatest attention should be paid to the appearance of fire-clay, which is generally found a certain leader to a bed of coal, either thick or thin. In places of this description the coal is rarely to be seen, having been decomposed, and washed away at the edge; and the roof of the coal, whether sandstone or slate clay, is found in contact with the floor or fire-clay. Care must, however, be taken not to confound decomposed light blue slate clay, with fire-clay, as the external characters are very similar, and very difficult to be distinguished by an inexperienced eye. The difference, however, may be ascertained with certainty, by subjecting part of the doubtful substance to a white heat, when the decomposed slate-clay will assume a red colour on cooling, and the fire-clay will become white, or yellowish white, and extremely hard. If the heat applied be strong, the fire-clay will be sufficiently hard to scratch glass.

OF THE COAL DISTRICTS OF IRELAND.

If we except the Leinster district, my knowledge of the coal districts of Ireland is as yet very limited. And, though each in its turn will form the subject of a separate Report, I think it right to draw attention to them in this place, by giving such general information as I possess, respecting their situation and circumstances. Coal has been discovered in more or less quantity in seventeen counties * of Ireland; but I

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* The counties are, Antrim near Ballycastle; Donegal north of Mount Charles; Tyrone in the Ulster coal district, and at Drumquin; Fermanagh, north continuation of the Connaught coal district, and at Petigoe; Monaghan near Carrickmacross; Cavan near Belturbet; Leitrim and Roscommon in the Connaught coal district; Westmeath near Athlone; Queen's county, Kilkenny and Carlow, in the Leinster coal district; Tipperary, continuation of the same; and Clare, Limerick, Kerry, and Cork, in the Munster coal district.

believe the island contains but four princi coal districts, viz. the Leinster, the Munst the Connaught, and the Ulster. The two f mer contain carbonaceous or stone coal, * a the latter bituminous or blazing coal.

The Leinster coal district is situated in t counties of Kilkenny, Queen's county, and cou ty of Carlow. It also extends a short distan into the county of Tipperary, as far as Kil naule. This is the principal carbonaceous c district. It is divided into three detached par separated from each other by a secondary lim stone country, which not only envelopes, but continuation passes under the whole of t coal district; a fact, which was indisputab though accidentally, proved by the Gra Canal Company, who sunk a pit throu eighteen yards of black slate-clay, and flin slate, into the limestone in search of coal. T Leinster coal district is therefore of subseque formation to the limestone.

It has been asserted by some philosophe that this coal district belonged to the transiti

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* Slaty Glantz coal of Werner.

rocks of Werner; and if so, the great limestone district of Ireland must be considered as transition * limestone. There are however strong grounds for believing that this is not the case. First, it certainly overlays the grey wacké country of Kildare, between Rathcoole and Kilkea Castle; and along the junction, masses of coarse grained red sandstone are visible at the surface, but I never found any in *situ* in the whole line. However, the detached masses, which are found along the line of junction, and in no other place, prove that the native bed of the sandstone rock must be near the edge of the grey-wacké country, and it is most probably interposed between it and the limestone. That the limestone does actually lie above the sandstone in some places is certain. It may be seen at Castlebar, and in other parts of the county of Mayo. And as there is no interruption in the limestone country between Dublin, Castlebar, and Kilkenny, it is consequently similar in these places.

From the position alone of the limestone, it might be determined to belong to the flœtz or horizontally stratified rocks; but, as an additional proof, the characters of the limestone itself are different from those attributed to transition limestone, as the stratification of the former is for the most part nearly horizontal, and the rock contains irregular beds, and immense quantities of rounded masses of Lydian stone, much resembling the nodules of flint contained in chalk beds.

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* The terms Primary, Transition, Secondary, Formation, &c. &c. have been adopted as words in common use, but in this Report no theoretical signification is meant to be implied by them.

This rock also contains petrifactions in profusion, as madrepores, hellecites, archites, entrochites, &c. From these data then, we may conclude, that the great limestone valley of Ireland is composed of *flœtz*, not transition limestone, and consequently, that the coal strata, incumbent on it, cannot belong to the transition series. These observations may appear out of place in a practical work; but the first step toward the general improvement of mining must be to diffuse a knowledge of the geology of the country; and the more accurately, and scientifically we commence, the more perfect and satisfactory will be our conclusion.

The Munster coal district occupies a considerable portion of the counties of Limerick and

Kerry, and a large part of the county of Cork. It is by much the most extensive in Ireland; but as yet there is not sufficient information respecting the number, extent, or thickness of the beds of coal it may contain.

Coal and culm for near a century have been been raised in the neighbourhood of Kanturk in the county of Cork. At Dromagh colliery I understand the work has been carried on to a very considerable extent, and its annual supplies of coal and culm have materially contributed to the agricultural improvement of an immense extent of the great maritime and commercial counties of Cork and Limerick, which must other wise have continued neglected and unreclaimed.

Many circumstances combine to make the examination of this district of peculiar interest and importance,—and as a recent application has been made by the Cork Institution to the Dublin Society, to aid the undertaking, it is probable that this immense district will shortly be minutely explored; from all that has been ascertained it is very clear that the dip of the beds and the quality of coal differ materially from those of the Leinster district. In the Munster district the beds run east and west, and dip to the south, forming an angle of forty-five degrees. In the Dromagh colliery, where all the beds which have been discovered have been successively and in general successfully wrought, four beds incline on each other, and at no greater distance than 200 yards. The first of these beds is a three feet stone-coal, and is the leading bed. All faults, checks, and dislocations, similar to those which are discoverable in this bed, are in general to be encountered in the other three; the names of the four beds are, the *coal bed*; this lies furthest to the north; the *rock-coal*; so called from its being comparatively of harder quality than the other beds; the *bulk bed*; so called from its contents being found in large masses or bulks; and *Bath's bed*; so called from the name of a celebrated English miner, by whom it had been many years ago discovered and worked; the coal bed consists of three feet solid coal, and is not sulphureous; the rock-coal, is nearly of the same thickness with the leading bed, but is very sulphureous, and having the soundest roof, is the most easily wrought. The other beds are of the culm species, but of peculiar strength. Each barrel of culm has been ascertained to burn from nine to ten barrels of lime. The bulk bed forms immense bulks and masses of culm, in which the miners have frequently been unable to retain the ordinary directions of roof and seat.

No work has been undertaken in the Munster coal district to a greater depth than 80 yards. The present work at the Dromagh colliery is at that depth. It is heavily watered, and consequently expensively wrought. The quality of the coal and culm improves as the work descends. Mr. Leader, who is the proprietor of the Dromagh colliery, has kindly communicated to me all the surveys and reports, which, from time to time, have been received from the persons who have inspected and directed the works. The peculiar proximity of the beds, and the extraordinary diversity of their contents in the Munster district make the minute examination of this coal-field of deserved interest and importance to this country. The time I trust is not remote, when the great coal field on the left bank of the Blackwater will be found to contain mineral treasure altogether inexhaustible, and by the liberality of Parliament, and the judicious and patriotic exertions of the Directors of Inland Navigation, fully adequate to all purposes of domestic convenience, and of national utility.

The Connaught coal district stands next in order, of value, and importance, to the Leinster and Munster, and possibly may be found to deserve the first place, when its subterranean treasures shall be explored. At present nothing is known, except, that the outer edges of several beds of coal have been observed, but they have not been traced to any distance; so that their extent is by no means ascertained. The coal is of the bituminous species. This coal is particularly adapted to the purposes of iron works, foundries, &c. &c.; and the grey pig iron made at the Arigna iron works is among the very best smelted in the Empire. Lough Allen, the source of the River Shannon, forms a basin in the midst of this great district, which on this account appears to be formed by nature for industry and commerce; but the navigation has been neglected, and is at present in such a state, that none but boats of trifling burden, can ply on the river, between Lough Allen, and Lanesborough. However, the Directors General of inland navigation in Ireland are at present employed in completing the Royal canal, between Coolnahay and Tarmonbarry on the river Shannon; and it is to be hoped, that they will at the same time complete a navigable communication between Lough Allen and the Shannon; and repair and improve the navigation of that river downward to Lanesborough. This would be a sufficient inducement to the proprietors of coal in the neighbourhood of Lough Allen to open their works to a considerable extent, as they could not fail of having a very large demand for their produce, whenever the navigation between the lake, and the Shannon, shall be completed.

The Ulster coal district is of trifling importance, when compared with the foregoing. It commences near Dungannon, in the county of Tyrone, and extends in a northern direction to Coal island, and in continuation to the neighbourhood of Cookstown. No beds of coal worth working have hitherto been discovered between Coal island and Cookstown, but certainly the coal strata extend there. The principal collieries are at Coal island and Dungannon. The coal of this district is bituminous. I understand that indications of coal have been observed at Drumquin, in the county of Tyrone, and also at Petigoe to the north of Lough Erne. Possibly the coal formation may extend from the neighbourhood of Cookstown, westward to the north of Lough Erne.

Besides the foregoing principal coal districts, there are others of less consequence. Bituminous coal has been found in the neighbourhood of Belturbet, in the county of Cavan, and at the collieries of Ballycastle, in the county of Antrim; but the Antrim coal district is not very extensive. These collieries have been wrought for a number of years. The coal is of a slaty nature, and greatly resembles both the coal, and the accompanying rocks, which occur in Ayrshire, and probably they belong to the same formation. A very extraordinary discovery was made at these collieries about the year 1770. It is thus described by the Rev. Dr. Hamilton, in his Letters on the North Coast of the County of Antrim. " The miners in pushing forward an adit or level toward the bed of coal, at an unexplored part of the Ballycastle cliff, unexpectedly discovered a passage, cut through the rock. This passage was very narrow, owing to incrustations formed on its sides. On being sufficiently widened, some workmen went through it. In minutely examining this subterranean wonder, it was found to be a complete gallery, which had been driven forward, many hundred yards, into the bed of coal; it branched out into 36 chambers, where coal miners had carried forward their works; these chambers were dressed quite square, and in a workmanlike manner; pillars were left at proper intervals to support the roof; and in short it was found to be an extensive mine, wrought by a set of people, at least as expert as those of the present generation. Some remains of the tools, and even of the baskets used in the works, were discovered, but in such a decayed state, that on being touched they fell into pieces. Some of the tools appear to have been wood thinly shod with iron.

The great antiquity of this work is evident, from the fact, that there does not exist the most remote tradition of it in the country; but it is more strongly demonstrable from the sides and pillars being found covered with sparry incrustations, which the present workmen do not observe to be deposited in any definite portion of time.

The whole of the coal districts, which, as far as I know, occur in Ireland, have now been mentioned. Trials have, however, been made at Slane on the river Boyne, and also in the neighbourhood of Balbriggan and Rush. These trials were however on the edge of the district, near the junction of the limestone. If the country contain coal, it will more probably be found in the interior than on the edge of the district. From this brief account of the coal districts it appears, that very extensive tracts of coal country exist in Ireland; but none, if we except the Leinster district, have been examined; yet the Munster coal district is in extent greater than any in England, and may probably contain inexhaustible beds of coal,

GEOLOGICAL AND MINING SURVEY

OF THE

LEINSTER COAL DISTRICT.

THE Leinster coal district is situated in the south-eastern branch of the great limestone district of Ireland, and the coal strata rest upon the limestone rock. This district of coal occupies small portions of the Queen's county, and the counties of Carlow, Kilkenny, and Tipperary. It is divided into three distinct parts by limestone rocks, which rise from beneath the coal strata.

Nearly the whole of the coal, that has been hitherto discovered, or that I have been able to trace, is contained in the eastern and most extensive division; toward which my attention has consequently been particularly directed.

This part of the coal district is bounded on the east, west, and south, by two great rivers, the Barrow and the Nore, which run immediately at the base of the colliery hills. The Barrow is navigable from Athy, where it joins the Grand Canal to the sea, below Waterford. The navigation of the Nore is of little use in its present neglected state.

The general appearance of the coal country, when viewed from a distance, is that of a very steep ridge of high land, running in a direct line many miles, rising from 800 to 1000 feet above its base, and apparently flat on the summit. It preserves this character on every side. But when viewed from the eminence itself, it resembles a great barren table land, rising precipitately above a flat and highly cultivated country.

It has already been observed that the coal country is surrounded by, and rests upon limestone. This limestone exhibits some remarkable appearances in the neighbourhood of the coal strata. It is not meant to theorise on these appearances, but as they are uncommon facts, a brief description of them may be useful.

The most important are the great dislocations, which have evidently taken place at, and near, the point, where the coal strata cover the limestone—the parallel disturbance in the coal strata, and the apparent change in their nature; the occurrence of irregular beds and veins of brown spar rock (siderocalcite of Kirwan) traversing the limestone, and frequently containing angular fragments of it, which have been detached from the rock; and lastly the vast caves of limestone, which occur near the point of junction of the calcareous and coal strata.

In examining the limestone strata on any side of the coal country, the appearances are so similar, that a description of one part will give a perfect idea of the whole. We may select therefore the limestone valley between the granite country, two miles to the east of the town of Carlow, and the coal country two miles to the west. The limestone valley is only four miles broad at that point, and on this account it has been chosen as the line of the great east and west section (No. 2.) which comprehends in a small extent a granite, limestone, and coal country.

DESCRIPTION OF THE LIMESTONE VALLEY.

At the base of Brown's hill, two miles to the east of the town of Carlow, the granite country is covered by stratified siliceous limestone, dipping 60° west of north, at an angle of 10° from the horizon. The colour of the limestone is light greyish blue. It contains numerous petrifactions, chiefly of bivalve shells, and burns into lime with great difficulty. The analysis of it is as follows;

Carbonate of lime............	95.
Silica with a tinge of iron...	4.50
Carbon........................	0.50
	100.

The stratification is quite regular between the granite country and Carlow; but the colour and character of the limestone change, as the beds accumulate, or as they are further removed from the granite. Half way between the junction of that rock with the limestone, and the town of Carlow, the colour of the limestone is dark blue, and madripores are visible, but rarely any other petrifactions. The beds in this part are extremely vesicular, and the numerous cavities are coated by a series of different fossils; that next the limestone is generally calcareous spar, which is covered by crystallised siderocalcite or brown spar, from which numerous rock crystals shoot in every direction. Sometimes crystals are found detached, having the prism and both pyramids quite perfect.

On approaching to Carlow the limestone becomes more siliceous, and of a still deeper colour. In the quarries at the town, the colour is black, and the texture fine-grained; and it is cut and polished, and used for chimney pieces, which are similar to those of Kilkenny; but, as the rock is not quite so close-grained, the lustre of the polished surface is less striking. The limestone to the west of Carlow is of a lighter colour, and much purer, than to the east. In the western quarries, for the first time, Lydian stone makes its appearance in quantity, both in irregular beds, and round nodules. The limestone becomes still lighter in colour, and finer in quality, as we ascend toward the base of the colliery hills. Some specimens of it, from the highest quarries, were found to be composed solely of carbonate of lime, with a trifling residuum of carbon, less than one quarter per cent. The number of petrifactions in the upper quarries is immense; they consist chiefly of madrepores, encrenites, trochites, camites, pectinites, hellecites, mitillites, &c. &c.

On approaching the point, where the coal strata join the limestone, the stratification is generally disturbed; and the rock, from being solid and compact in its nature, becomes shivery, and breaks into indeterminately angular fragments of small dimensions. The quantity of Lydian stone is greatly encreased; the actual point of contact of the limestone and coal rocks is rarely visible, owing to the great disturbance and dislocation of the strata. At Spring-hill, two miles to the west of Carlow, this shivery limestone is covered with about thirty feet of Lydian stone, arranged in very thin beds, which rarely exceed two inches in thickness. The stratification undulates and varies so much, that it is almost impossible to trace it. The Lydian stone appears to pass into slate clay, and certainly no division exists between them. Specimens may be easily collected, forming a perfect transition from the Lydian stone, with a large conchoidal fracture in every direction, passing through a bed of indurated slate, (which has an earthy conchoidal fracture, and rings when struck) to the perfectly soft black slate clay which succeeds. These appearances are more or less striking in different places. They are peculiarly evident to the south of Spring hill, and at the limestone quarry to the south of Old Leighlin. In the latter place the Lydian stone contains numerous siliceous petrifactions. The disturbance of the limestone and the coal strata are also very visible at this quarry, twenty yards from the junction of the limestone, dips 55° E. of N. at an angle of 10° from the horizon; approaching close to the hill, the angle of the dip encreases to 20°.; at the junction, or where the limestone is covered by flinty slate, to 40°. However the stratification is not regular for ten yards in any direction. The dip of the coal strata on ascending the hill is at first equal with that of the limestone and flinty slate, but it gradually becomes flatter, and at the summit the inclination does not exceed six degrees from the horizon.

The succession of rocks, visible at Old Leighlin, is as follows, commencing at the bottom of the quarry, and ascending.

		FEET.
-	Dark bluish grey limestone	10
2.	Irregular black Lydian stone, containing siliceous petrifactions	2
3.	Light grey limestone, (shivery in the beds, the uppermost contain Lydian stone)	20
4.	Lydian stone, containing numerous siliceous petrifactions	3
5.	Flinty slate, in very thin beds, the uppermost of which graduate into slate clay, and contain balls of clay ironstone of a dark blue colour	30
6.	Sandstone flag	200

This rock continues to the summit of the hill, where it varies very much in quality, and passes, from hard sandstone, into soft micaceous flag which divides into thin laminæ, from one inch to one tenth of an inch in thickness.

Beside the irregularities above described, beds of brown spar rock * are frequently met with near the point of junction of the limestone, and the rocks belonging to the coal series. Examples of this nature are more frequent on the southern and western boundaries of the coal district, than on the northern and eastern. At

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* Brown spar (the siderocalcite of Kirwan) is described, in all treatises on mineralogy, as a simple mineral which is usually found in veins, but I believe no mention has hitherto been made of its occurring in vast beds interstratified with limestone.

Jenkinstown, and to the north-west of it, the brown spar rocks occur very frequently in great quantities, particularly at Tullyglass. At this point the strata dip north at an angle of 7° from the horizon. The section visible, is as follows: First light blue limestone, then brown spar rock, which varies from greyish blue to a yellowish white. This rock is highly crystalline, and frequently contains madrepores, but I never observed any other species of petrifaction. The brownspar is covered by flinty slate, over which is a perpendicular cliff, of yellowish brown sandstone of a shining lustre, which when struck, flies into small angular fragments, generally of three sides only. The face of the rock frequently assumes a columnar appearance, and many of these three-sided columns, (if I may so call them) are three or four feet long, and six inches broad on each of the faces. The peculiar character, and remarkable appearances of the brown spar rock are not so clearly exhibited near the junction of the calcareous and coal strata, as in some places a short distance from them. The calcareous cliffs on the north side of the river Nore, between Kilkenny and Bennet's Bridge, are well worthy of attention, as they bring to light some curious facts. The accompanying sketch (Plate I.) of their general appearance, will serve more clearly to elucidate the following description.

The first rocks visible are the limestone quarries at Sign, close to Kilkenny. In these quarries there are five beds of limestone, each about five feet thick. They increase in darkness of colour and fineness of grain, in proportion to their depth. They dip to the east. Below the quarry, near the bank of the river Nore, there is a cliff of brown-spar rock, which covers the limestone. The beds seldom exceed two feet in thickness. The colour of the upper beds in the cliff is yellowish white, but the lower are of a dark greyish blue colour, and contain madrepores. In one part of the lower bed, an irregular junction of the limestone with the brown spar rock is visible, the latter resting on the former, but not adhering to it. The brown spar rock extends a considerable distance down the river, but it is visible only at intervals, being covered with clay and gravel. Below the mills there is a low cliff of this rock; the beds dip to the east, and are evidently a continuation of the first cliff. Three quarters of a mile further down the river, *limestone* rocks appear forming a crag about eighty yards long. The dip here is west, and from this change we may conclude that the limestone rocks form a basin, the centre of which is filled up with brown spar, as represented in the accompanying section.

This supposition is strengthened by the fact that the limestone does undulate in the cliffs, on the south side of the river, between Archer's

Grove and Kilkenny. Lower down, though not exactly at the edge of the river, the limestone again dips east, and covered with brown spar, which extends to the marble mills. At this point the limestone again appears dipping west, and evidently passes under the brown spar. Below the marble mills, the limestone extends for a quarter of a mile, and forms a perpendicular cliff. As it approaches a little valley, the rock is covered with limestone gravel, but certainly extends as far as the valley, and there ends abruptly. On the opposite side, brown spar rocks commence, and continue for a considerable distance in regular beds: this regularity is at length interrupted by immense masses of limestone being found *enveloped* in the brown spar rock. These masses are so large, that the stratification still remains, although the extremities and edges are much shivered and broken.—See Sketch Plate, No. 1. The whole cliff is however quite solid, and the brown spar appears to have insinuated itself into all the crevices and fractured parts of the limestone. Beyond the extremity of the last included mass of limestone, the brown spar forms an irregular vein, between the included mass, and a cliff of limestone, which commences on the lower side. This vein (if it may be so called) is completely united and continuous with the beds of brown spar, both above, and below the included mass of limestone.

Below this extraordinary place the cliff is composed of regularly stratified limestone, for one hundred yards in length, when it is traversed by an irregular vein of brown spar, running north east, and dipping south east. A short distance beyond is a second vein, containing much calcareous spar, and some small angular fragments of limestone; and afterwards the limestone cliff is traversed by a third vein of brown spar, similar to the first. Beyond this vein, the limestone cliff remains undisturbed for a quarter of a mile, and then ends abruptly at a narrow glen, forming a perpendicular cliff. On the opposite side of the glen, strata of brown spar commence with equal abruptness, and continue without interruption to Bennet's Bridge, where they are covered by hillocks of limestone gravel. These latter beds of brown spar dip 30° west of north; the colour varies from brownish red to reddish white. The mass is extremely compact, and highly crystalline when fresh broken; but when exposed to the atmosphere the surface generally decomposes.

The abruptness with which the limestone and brown spar rocks end and commence, is observable in many places in the neighbourhood of Kilkenny, as well as in those I have mentioned; and where it takes place, these rocks are generally separated by a deep and narrow glen. Perhaps the most remarkable example of this fact is at Coolgrany, four miles south east of Kilkenny.

At this place there is a deep glen running south from the colliery hills. It is bounded on the east and west sides by perpendicular cliffs, which resemble each other so much both in the thickness and general character of the beds, that without further examination it might naturally be concluded, that at some period, a torrent of water had carried away the rocks that originally filled up the space between the cliffs. On nearer inspection, however, it will be found that the rocks on the west side are composed of brown spar, and at the east of blue limestone. The strata on each side dip 30° east of north at an angle of 10° from the horizon.

The third, but perhaps the most remarkable phenomenon that is met with in the limestone country, is the frequent occurrence of caves of various sizes, in the limestone, close to the point where the coal strata cover that rock. The caves of Dunmore and Clopooke, the one situated to the south and the other to the north of the coal district, are among the most extraordinary in the empire. Considerable streams of water flow out of the cave at the Peak, and others in Derbyshire, which are also in limestone. Many have attributed their origin to the constant friction of the water, but no water issues from the caves of Clopooke and Dunmore. Those of Clopooke are on an elevated situation, are very numerous, and are generally in the form of long and narrow passages. Approaching the cave of Dunmore, you descend into a deep, circular, open cavity, at the bottom of which you descry the rude but magnificent entrance to the cavern.

Without theorising on any of the facts above described, we may fairly draw this general conclusion, that great convulsions have taken place at some period in the neighbourhood of the Leinster coal district, which have not only caused great irregularity in the stratification of the exterior boundary, but also throughout the whole of the interior of the district.

DESCRIPTION OF THE PRINCIPAL DIVISION OF THE LEINSTER COAL DISTRICT.

The largest and most important division of the Leinster coal district, is 15 miles long, between Timahoe, on the north, and Kellymount on the south; and 11 miles broad, between Ballickmoyler on the east, and Ballyragget on the west.

It has already been mentioned that the district is surrounded by limestone, which inclines or dips on all sides toward the coal country, and that the coal strata rest on the limestone, and dip conformably with it.

The character of the interior of the coal country is wild and dreary, the greater part being uncultivated, and nearly uninhabited. The surface is very uneven, and the hills of the interior, though less elevated, are similar in appearance to those which compose the outward boundary; being formed into steep, straight and long ridges, which are nearly flat on the summits.

The soil on the surface is generally composed of stiff clay, either yellow, blue, or white, and the summits of the hills are invariably covered by shallow bog.

There are two great vallies in the interior of the coal district, those of the rivers Dinan and Deehan. The former has its source near the summit of Clogrennan-hill, which bounds the coal country on the east, and runs westward by Coon, Uskerty and Damerstown, where it is joined by the Deehan; it then bends its course to the south-west, and falls into the river Nore below Jenkinstown. The river Deehan has its source near the northern boundary of the district, and running south-west by Clogh to Castlecomer, joins the Dinan, a mile and a half below that town. The banks of these rivers are generally extremely steep, and are frequently composed of clay mixed with limestone gravel. This most useful substance also occurs on the most elevated ground in the coal country, forming small hillocks or caps on the summits of the hills.

OF THE STRATIFICATION.

On taking a general view of the stratification of the Leinster coal district, such a picture of dislocation, undulation and irregularity, presents itself that it is almost impossible to understand, or trace any bed for a mile in length; and nothing but constant recurrence to the same place, and familiar acquaintance with the external aspect of particular beds of sandstone, has enabled me to ascertain with any precision, the extent and relative positions of any two beds within the district.

The stratification of the exterior hills of the district, on every side, is found to incline toward the interior of the coal country, and nearly at right angles with the declivity: on reaching the summit, the strata continue the same inclination, and are found to dip nearly parallel to the slope of the hill. On meeting one of the interior hills, the dip frequently changes to that of the inclination of the hill, and the strata bend over on the summit forming a saddle back, and descend into the next valley: on meeting a second hill, the inclination of the strata again changes to that of the hill, and so on across the country. This is the character of the stratification, on the great scale; but in addition there are minor undulations, and such frequent slips * or down throws of the strata, as almost to baffle research.

That part of the coal district, situated to the north of the river Dinan, and east of the Deehan, is by much the most regular, and is the chief repository of coal. To the south side of the Dinan and west of the Deehan, no coal worth working, except that of Firoda, has been discovered; and from my own observations I am inclined to think none exists. If there does, the undulating stratification, which runs parallel with the irregular face of the country, would render it impossible either to work or unwater more than a few acres in any part.

The great section, plate 2, which crosses the coal district from east to west, affords an example of the regular and the undulating stratification.

Much time and labour have been expended in rendering this section as accurate as possible. The distances were ascertained by chaining the surface, and the heights partly by levelling, and

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* By slips, or down throws is meant the sudden change in the level of the strata, which is frequently observable in all the coal fields, by the slipping or falling of one part of the coal field, from its original position to a lower one. This fact is clearly represented in plate, No. 3, where it is shewn that the coal strata, in the Lordship colliery of Castlecomer, have been thrown down 70 yards by a slip.

partly by angles of elevation and depression, taken with a large theodolite. The eastern part of the section crosses the most regularly stratified part of the coal district, and it is hoped by means of it to give an accurate view of the relative position and extent, in an east and west direction, of the different beds of coal and other substances as they occur, commencing with the lowest, which rests upon the limestone, and ascending regularly, ending with the uppermost bed of rock, which is met with in the district.

But previous to entering into the minute detail, either of the section or of the tracings of the different remarkable beds, it may be proper to give an outline of the general mode of proceeding, and the reasons for adopting that mode.

It has been the general opinion of the colliers, that there exists but one bed of coal in the Leinster coal district, and though it is admitted that the coal at different collieries presents different aspects, and is of various thickness, still those who think at all on the subject, attempt to account for these variations, by the disturbances and alterations created by slips and undulations of the strata, or faults, as the colliers universally term all irregularities. The first object was therefore to ascertain the real state of the case, and with this view the section, plate No. 2, was commenced; by means of it, and the section, plate No. 3, which crosses the country nearly at right angles, to No. 2. It is proved to a certainty, that the district contains eight beds of coal, one above the other, all of which are workable; this being accomplished, the next object was to trace the line of the outgoing or crop of the lowest workable bed of coal in the district. This must at all times be an object of great importance to the mineral surveyor. It serves him as a line to bound the extent of his researches; and if he be acquainted with the perpendicular distance between the first and second beds of coal, by ascertaining the angle and direction of the inclination of the strata, he will by practice be enabled to determine with tolerable accuracy, the horizontal distance between the outgoings of the first and second beds, and so on to the third, fourth, &c. But this mode of proceeding becomes absolutely necessary in countries similar to the Leinster coal district, where the outward face of the boundary hills presents numerous deep gullies and mural precipices, in which the whole stratification of the mountain is exposed, but where the rocks of the interior of the district are almost universally hidden from view, by a deep clay covering. The plan which was pursued therefore of first tracing the lowest workable bed of coal round the district, as it is the only one that appears on the face of the precipices, was that most likely to lead to an accurate knowledge of the general stratification, and the probable position of the outgoings of the different beds of coal, which occur in the interior.

For the sake of greater clearness the table of the different rocks represented in the sections, plates No. 2 and 3, is here given: the peculiarities and extent of such of the beds as may be useful or are remarkable, will afterwards be described.

TABLE.

No.		Feet.	Inches.
1	Limestone, which covers the Granite, about	3000	0
2	Black slate clay, which in the upper beds become greyish blue micaceous slate clay,	300	0
3	Alternating beds of sandstone and slaty sandstone..	25	0
4	Finegrained black slate clay	30	0
5	Alternating beds of sandstone and slaty sandstone	30	0
6	Greyish blue irregular micaceous slaty sandstone, which gradually passes into black slate clay, with iron stone..................	35	0
7	Grey micaceous sandstone.......................	20	0
8	Spheroidal slate clay containing balls of clay, ironstone frequently one foot thick..	30	0
9	Grey sandstone in thin beds....................	32	0
10	COAL, slaty glantz or carbonaceous, in very thin laminæ, between black slate clay and fireclay..	1	6
11	Small spheroidal slate clay containing clay ironstone balls..	20	0
12	Irregular grey sandstone.........................	8	0
13	Slate clay	1	0
14	Grey sandstone...	10	0
15	Black slate-clay, containing beds of different thicknesses of clay ironstone, sometimes they are one foot	65	0
16	Calcareous sandstone.................................	1	0

No.		Feet.	Inche
17	Fireclay	0	6
18	Black slate clay	4	0
19	Blackish blue slate clay, containing thin but regular beds of clay ironstone	35	0
20	Calcareous sandstone	0	6
21	Calcareous fireclay, containing cornuammonis	0	4
22	Black slate clay	6	0
23	Bluish black slate clay	85	
24	Alternating beds of sandstone, slaty sandstone and slate clay	60	0
25	Very hard clayey sandstone, containing impressions of rushes	2	0
26	Fireclay	1	0
27	Rossmore Coal	0	10
28	Black slate clay	60	0
29	Grey sandstone, with thin beds of slate clay	45	0
30	Slate clay	40	0
31	Sandstone irregularly stratified	80	0
32	Clay stone, with impressions	1	0
33	Fire-clay	0	6
34	Coal	0	4
35	Black slate	1	0
36	Grey sandstone	3	0
37	Hard claystone, with vegetable impressions of rushes, &c.	4	6
38	Fire-clay	2	6
39	Slaty Coal Fire-clay Solid Coal Slaty Coal	4	5
40	Black slate	1	6
41	Slaty sandstone, hard	2	0
42	Slate clay	10	0
43	Slaty sandstone, thin beds	20	0
44	Grey sandstone	20	0
45	Slaty sandstone	18	0
46	Black slate clay	100	0
47	Slaty sandstone, with thin alternating beds of slate clay	160	0
48	Coarsegrained slate-clay, sometimes passing into slaty sandstone	200	0
49	Indurated claystone passing into sandstone	2	6
50	Fire-clay	2	0
51	Soft Coal, slaty...1F. 6I. Solid Coal..........1 6	3	0

	Feet.	Inches.
d grey sandstone; this bed usually co-rs the coal, but in some places there is bed of slate clay from one to four feet ick between it and the coal	18	0
L	0	1
rsegrained grey sandstone, frequently ntaining fragments of slaty sandstone d black slate clay	36	0
y sandstone	40	0
-clay	3	0
L	0	9
k slate clay	25	0
y sandstone	8	0
slate clay	5	0
y sandstone	10	0
slate clay	12	0
y sandstone	10	0
y sandstone	12	0
slate clay	8	0
y sandstone	9	0
k slate	8	0
y sandstone	1	6
k slate	3	0
R FOOT COAL	4	0
y coal or kelve	2	0
k slate clay with ironstone	15	0
y slaty sandstone	16	0
slate clay	6	6
slaty sandstone	8	0
y sandstone	14	6
slate clay	26	6
d grey sandstone	11	0
slate clay	20	0
y slaty sandstone	18	0
-clay, or coal seat	2	0
mmagh foot COAL	1	0
k slate clay, with balls of clay ironstone	13	0
y slaty sandstone	34	0
slate clay	4	0
y sandstone	35	0
-clay	0	6
L	0	2
k slate clay, with clay ironstone beds	25	0
y sandstone	4	0
slate clay	3	0

No.		Feet.	Inches
92	Grey sandstone	6	0
93	Seat rock, or sandstone, containing vegetable impressions	3	0
94	Fire-clay or coal seat	4	0
95	First bed of THREE FOOT COAL	3	3
96	Black slate clay with ironstone, containing muscle shells	36	0
97	Micaceous slaty sandstone	22	0
98	Grey sandstone slightly calcareous	15	0
99	Blue slate clay	3	0
100	Grey sandstone slightly calcareous	12	0
101	Grey slaty sandstone	9	0
102	Grey sandstone	1	0
103	Blue slate clay	1	6
104	Grey sandstone	1	0
105	Grey slaty sandstone	6	0
106	Hard blue slate clay, with ironstone	4	0
107	Sandstone with vegetable impressions (seat rock)	3	4
108	Fire-clay, or *coal seat*	1	0
109	COAL 1 0 Fireclay 1 6 COAL 1 0 Double seam	3	6
110	Blue slate clay with vegetable impressions of ferns, and small nodules of clay ironstone	17	10
111	Fire-clay, or *coal seat*	3	0
112	Upper bed of THREE FOOT COAL	3	0
113	Black slate clay	6	4
114	Clay ironstone	0	1
115	Blue slate clay	9	0
116	Clay iron stone	0	2
117	Black slate clay	3	0
118	Clay ironstone	0	2
119	Blue slate clay	22	0
	Total height above the granite	5246	7

DETAILED DESCRIPTION OF THE REMARKABLE BEDS WHICH OCCUR IN THE LEINSTER COAL DISTRICT.

No. 1. Limestone. The substance has already been described.

No. 2. Black slate clay. This substance has been observed to rest upon the limestone in every situation where the coal and calcareous strata were found in contact. In many places the lower beds resemble flinty slate, but as they ascend, or as they are further removed from the limestone, the flinty slate passes gradually into black slate clay. Balls of clay ironstone are frequently met with in the upper beds of black slate clay.

This rock is of various thickness in different places. In the wood of Clogrennan, two miles south-west of Carlow, a pit was sunk, and bored through 100 feet of this black slate clay, in search of coal, without reaching the limestone. At Spring-hill it exceeds 300 feet. At Old Leighlin it is about 80 feet; and further south it is frequently less than 30 feet thick. This bed is generally so very black and carbonaceous, that in many places where borings have been made through it in search of coal, the borers judging from the black colour of the water, which issued from the borehole, have d clared that they found coal. But wherever pi have been sunk in consequence, nothing w met with but black carbonaceous slate-clay. tradition is still prevalent in the country th coal was found at Old Leighlin, and in oth places where borings have been made many yea ago through this black slate-clay, but that th borers were bribed to say there was none. Le detail would have been requisite respecting th bed of black slate-clay, had the fruitless tria already made been sufficient to prevent furth sinkings and borings: But country gentleme attend so little to these matters, and are so fr quently imposed on by crafty colliers, (who b ing too idle to work at the great collieries, a anxious to get well paid for sinking small pits that it has been deemed necessary to call th attention more particularly to this bed.

The black slate clay is covered by alternati beds of sandstone and slaty sandstone, (No. 2 In the line of section, and to the north of these beds are from 25 to 50 feet in thickness, b to the south they encrease immensely, and app rently in an equal proportion to the thinning the slate-clay. At Old Leighlin, Shanakill, Ke lymount, &c. where the great flag quarries a situated, these alternating beds are 300 feet thickness, and amongst them every variety flag, from coarse to fine grained, and from thic to very thin, may be found. The thickening the sand-stone and slaty sand-stone strata, to the south of the district, is not confined to this particular instance; for as far as the undulations in the strata permitted particular beds to be traced, it was invariably found that all the sandstones increase in thickness as they proceed southward; and that the slate-clay diminish in equal proportion; and therefore, in speaking of the general character of the district, it may be said, that to the north of the river Dinan, coal and slate clay predominate; and to the south, sandstone and slaty sandstone: and also where the slate clay and coal are found, the stratification is regular and has a uniform inclination; but where sandstone predominates, the stratification undulates and varies in a few yards, from horizontal to vertical. This irregularity in the sandstone is not entirely confined to the south of the Dinan; for in the midst of the coal fields, undulating beds of sandstone rise up from beneath the coal, and form steep hills, at whose base the coal is thrown up to the surface, and terminates.

In the beds No. 4, 5, 6, and 7, there is nothing remarkable.

No. 8. Spheroidal slate clay, containing balls of clay ironstone, frequently one foot in thickness. By spheroidal slate clay, is meant a species of hard slate, which on being exposed to the atmosphere, divides into large flattened spheroids, on being struck the outer coat comes off, and leaves a smaller spheroid, which being again struck, a second concentric coat is separated, and so on till the nucleus is met with, which sometimes is composed of hard clay stone, and sometimes of clay ironstone. The ironstone contained in this bed is very rich, and in many places remains of ancient excavations are still visible where this bed has been wrought in search of ironstone; and indeed some of the iron furnaces * may yet be seen.

There is nothing remarkable in No. 9.

No. 10. *Simple carbonaceous or uninflammable coal,* in very thin laminæ, between flakes of black slate clay, and fire clay. This bed is only remarkable from its being the first in which coal occurs. Many trials have been made on it in different places, but none were found worth following, owing to the great admixture of slate and fire clay.

Nothing worth describing occurs between the beds No. 10 and 29.

No. 21. Calcareous fire clay, containing impressions of the cornu ammonis, four inches thick. This bed is particularised, merely from its being the only one in which marine shells were found, if we except the occurrence of impressions of muscle shells in balls of clay ironstone, which have been met with, though very rarely, in some of the uppermost beds of slate clay.

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* In Killeshin Glen, in examining the remains of a small blast furnace, which has been of a square form instead of the usual circular one, I found some small pieces of cast iron, of excellent quality, amongst a heap of slag.

No. 25. Very hard clayey sandstone, containing impressions of rushes. This species of rock, and fire clay which rests upon it, occur immediately below all the regular beds of coal (except the four foot coal,) which occurs in the district. It is called seat rock, and the fire-clay seat clay, or coal seat. The impressions of rushes they contain are never found in the other rocks.

No. 26. Uninflammable coal, or mineral charcoal. This bed of coal varies in thickness from 10 to 16 inches. It may be said to be the first bed of coal which occurs above the limestone: for the slaty substance already mentioned hardly deserves the name. This bed of coal, which in future may be distinguished by the name of *the Rossmore foot coal*, from its having been first worked on Rossmore-Hill, is composed of two distinct substances; conchoidal or solid coal, which occupies the upper part of the bed, and is generally from six to eight inches in thickness, and soft slaty coal, called *kelve* by the colliers. The colour of this coal when fresh broken, is brownish grey with a reddish hue: when exposed to the air, it becomes reddish brown. Its fracture is conchoidal in every direction. It is usually quite free from sulphur, and when burned it leaves about 10 per cent.

of white ashes. Being the lowest, it is consequently of greater extent than any of the beds of coal that cover it. In tracing *the rushes bed of coal*, No. 39, which lays 250 feet above it, the Rossmore coal was also traced from Wolf-hill, on the north of the district, to Uskerty-wood, on the river Dinan, a distance of above 12 miles, and in this great extent the only material interruption in the continuity of the bed, is in the deep valley to the east of Turra-hill, through which the new colliery road from Carlow to Castlecomer has been made. The winding course of the outer edge of this bed of coal is not marked on the map as it might create confusion, but it runs nearly parallel to the outgoing of the first bed of slate-coal. The outgoing of this coal is almost in every instance on the face of a precipitous hill, and the dip is nearly at right angles to the declivity. This unfavourable circumstance has been sufficient to prevent many trials being made to work it. The most expensive attempt was undertaken by the grandfather of Mr. Hamilton, of Sheep-hill, in the county of Dublin. At his cost, a level of considerable length (now nearly closed up) was driven into Rossmore-hill to unwater the colliery, but when workings were attempted to be made on the coal, it proved to be but one foot thick, and could not be wrought to profit. Pits were also sunk many years ago in this coal in the valley below Ardalegle colliery near the line of the new Carlow road. And five years since Col. Rochfort of Clogrennan, in sinking a trial pit in search of coal, to the east of Clogrennan colliery, discovered this bed; but the strata sunk through in the pit were so much disturbed and broken, that he did not make any workings on it. These are the only trials worth noticing, that have been made on the Rossmore foot coal.

The next remarkable bed represented in the section is composed of sandstone irregularly stratified 80 feet thick. No. 31. This bed, or rather number of beds, is not only irregular in its stratification, but also in its thickness and composition. It frequently passes from sandstone into slaty sandstone, and even into alternating beds of sandstone and slate clay. Its thickness varies from 60 to 140 feet; it is also very irregular in respect to its distance from Rushes bed of coal which lays above it. In the line of section it is only 12 feet below it. At Clogrennan colliery it is 40 feet. This bed, though changeable in its constituent parts, is more frequently composed of sandstone of a greenish grey colour than of any other substance. It is rarely stratified horizontally or regularly, for any considerable distance; it constantly undulates; and when it happens to be the uppermost rock, it forms steep but irregular hills; one of the most remarkable instances of this kind is at Hunt's Park near Clogrennan colliery. Its appearance at this place is represented in section No. 4. It dips suddenly under the coal, forming a short curve, rises from beneath it again, at an angle of 60° from the horizon, and becomes the surface rock. It there forms a great undulation, half a mile in length, across the lands of Hunt's Park, and again descending, is once more covered by the coal. From Hunt's Park this sandstone may be traced in a western direction along the bed of the river Dinan, forming similar undulations, and when near the surface, interrupting the continuity of the coal, but particularly about Coon Bridge and below the wood of Uskerty. This great sandstone is divided into many irregular beds, but their number varies; I have counted 40, 50, and even 60. The texture is generally coarse grained, the colour of the upper beds is greenish grey, the lower ones are frequently smoke grey and yellowish grey, and are interstratified with beds of slaty sandstone and slate clay; and in some instances, as I have already mentioned, these rocks predominate. When this happens, the inclination of the strata is more uniform. This sandstone forms the most remarkable feature in those parts of the coal district, through which it can be traced, and from its proximity to the Rushes bed of coal, it serves as an excellent guide to lead to the discovery of its outgoing. Beds of coal are very rarely visible at the surface; they may sometimes be traced by the blackness of the soil, near their edge, but the most certain indication is the discovery of a bed of fireclay, or of sandy claystone with vegetable impressions called seat rock, which lays immediately below the coal; but when these beds happen to be covered with soil, the next resource is in some remarkable bed of rock, such as the sandstone above described, which occurs a few yards above or below the coal.

The beds between 31 and 39 exhibit nothing peculiar either in their appearances or composition. The thin bed of coal No. 34, is of no other consequence than as a proof of the identity of the Rushes bed of coal in different parts of the district, when the other accompanying beds have varied in their thickness and composition; and this leads to a general observation which I have made in this district, but which I believe is not peculiar to it, that the different beds of coal are much more regular, and differ less in quality and thickness, than any of the accompanying strata.

FIRST BED OF SLATE COAL OR RUSHES COAL.

Without its being known to be the same bed, this coal has been discovered and partially worked in several places for many years; but by the assistance of the thin bed of coal, No. 34, and the great bed of sandstone which lays below it, I have identified it at the different collieries, and have traced its outward edge for ten miles through a part of the country, where no coal had before been discovered or supposed to exist. To avoid tedious description I beg to refer to the map, for the line of the outgoing of this bed of coal. The different places in which it has been worked are Wolf Hill, Ballylihane, Corgee, the Rushes, Moira, Courlean, Clogrennan Hill, and Agharue; excepting Moira, Clogrennan Hill and Agharue, these several collieries are situated on the summits of the hills which form the outward boundary of the district; and the coal dips from the summit inward toward the interior of the district. In most places the dip is much quicker than the fall of the surface, and consequently at a very short distance from the outer edge, the coal becomes inaccessible, from the impossibility of freeing it from water. The Wolf Hill and Clogrennan collieries are the only ones at present at work. The former is unwatered by a level which has been driven at a considerable expence into the hill; but the field of coal commanded by it is trifling. Ballylihane colliery has been idle for many years; the coal has only been worked where it was shallow, the deep part remains untouched. The Corgee, Paulitien, and Rushes collieries are in the same situation. The Grand Canal Company drove a level some years ago to unwater part of Corgee and the Rushes collieries, but as yet no use has been made of it. The deepest pit ever sunk in the Rushes colliery is 32 yards, and the whole of the water was pulled to the surface. Immediately to the south of the collieries of Paulitien and Corgee, that is to the dip, there is a deep valley, in which the strata appear to be much dislocated and broken. Between the collieries of Corgee and the Rushes, there is a great clay dyke running nearly north and south. It cuts the coal, but does not appear to have disturbed its horizontal position. The exact position of this bed of coal at Courlean colliery, situated to the north of Killeshin Glen, may be seen by reference to the section, No. 2. which runs through the centre of it. Very little has ever been accomplished at this place. Two pits were sunk, and the coal found is reported to have been good, but no workings of any extent were made. Between the collieries of Courlean and the Rushes there is a deep valley, across which, owing to a great clay covering, it was impossible to trace the coal, or to ascertain whether or not it is thrown out by the sandstone undulation which forms Turra Hill. But the outgoings of this coal were traced in a western direction from the pits at Courlean to the head of Killeshin Glen, and from thence along the summit of Rossmore Hill, and the head of Glasha Glen to Colonel Rochfort's colliery at Clogrennan Hill. Owing to the peculiar situation of the coal it will be almost impossible to work any part of it from the head of Killeshin glen to the new Carlow road, as it crops out on the face of the precipice, and dips directly into the hill. Between Killeshin glen and Clogrennan colliery it lies near the summit of the hill, but unfortunately the coal is but 16 inches thick: this was ascertained by two pits sunk in it many years since, which were abandoned in consequence; for none but those well skilled in the management of collieries, are likely to succeed in working a bed of coal of that thickness.

The colliery at Clogrennan has been working many years, but on a very small scale. The first discovery of the coal was near the southern edge in the insulated hill represented in section No. 4. In this place the bed was from 14 to 16 inches thick, and the quality so bad that it hardly paid the expence of raising. Other pits were subsequently sunk to the north of the first, and though the quality of the coal was better, still owing to the encreased depth of the pits, the expence exceeded its value. After ascertaining, last summer, that the Clogrennan coal was a continuation of the first bed of slate coal, a borehole was made, considerably to the north of the old workings, to prove the thickness of the coal; for when the beds were traced, and *the angle and direction of their dip* determined, it was easy not only to foretel with confidence that the coal was there, but also with tolerable accuracy the depth at which it lay. Contrary to the expectation of the colliers the event proved that I was right. Having discovered the coal by boring, it was recommended that a pit should be sunk still further north, in a situation where by calculation it was ascertained that the depth of the coal below the surface would be but *nine yards.* When sunk, the coal proved to be much superior in quality to that formerly worked, though the depth from the surface in the old pits was 20 yards and upwards. It usually happens that beds of coal are compact in proportion to their depth below the surface, at least till they arrive at the depth of 40 or 50 yards. The anomaly in the present case may be accounted for by the disturbance created near the southern extremity of the bed of coal, by the undulation of the sandstone, as represented in section No. 4.

From Clogrennan colliery to the north of the sandstone undulation, the coal dips toward the lands of Hunt's Park at a considerable angle; but in the hill of Ardough the strata change their inclination and rise with it.

In the stream which forms the boundary of the counties of Kilkenny and Queen County, to the west of Hunt's Park, the outgoing of the coal may be seen in many places very near the surface. It is therefore probable that a considerable field of the coal will be found at no great depth in Hunt's Park. Between the County of Kilkenny boundary and Clogrennan colliery, as appears from the map, the outer edge of this bed of coal has been traced for a great distance in the county of Kilkenny, both to the north and south of the river Dinan. No trials have hitherto been made on the north side, but on the south at Agharue, Sir Richard Butler, Bart. sunk some pits, close to the road between Castlecomer colliery and Leighlin Bridge. These pits were sunk in the worst possible situation, close to the crop of the coal, and though a water level might have been carried along the coal, from the outgoing on the face of the precipice near the river Dinan to the pits, it was never attempted; but the whole water of the colliery, which was very considerable, was drawn up by manual labour through the pits to the surface. The coal was so bad, and the water so expensive to raise, that this colliery was soon abandoned. Had the pits been sunk further to the north east, and a proper level been driven to carry off the water, Agharue colliery might possibly have been made to answer. In the lands of Raheen, immediately opposite Uskerty wood, the first bed of slate coal has been discovered cropping out in two or three places on the face of the hill, and at the regular distance below it the Rossmore foot coal already mentioned has also been traced. Some pits have been sunk a little to the dip on the first bed of slate coal, and six inches of solid coal, and thirty inches of slaty coal, or kelves, are said to have been found.

Owing to the thick covering of limestone gravel, it was impossible to trace this coal on the south side of the Dinan for any considerable distance, but from the occurrence of the great sandstone bed, and from finding large blocks of *seat rock* in two of the streams of Damerstown, it is probable that a thin bed of coal extends through both upper and lower Damerstown, but at what depths it is not possible to ascertain without sinking or boring.

When the first bed of slate coal had been traced nearly without interruption, from Wolf Hill in the Queen's County to Uskerty wood in the County of Kilkenny, I entertained sanguine expectations of being able to complete the circuit; but on crossing the Deehan river, these expectations were not fulfilled, at least not satisfactorily so, for stream after stream and precipice after precipice were examined, without discovering either coal, seat clay, seat rock, or even the great sandstone.*

* Since this report was written I have again visited Castlecomer, and in attempting to trace the first bed of slate coal to the north of Eskerty wood, I discovered a number of beds of sandstone in the glen of the rock of Foyle, which I believe to be the sandstone already mentioned that lies below the first bed of slate-coal; and though I did not find the coal itself, I am persuaded it is there, for at the regular distance below the sandstone strata I found a ten inch bed of coal resembling the Rossmore foot coal.

At Ballyhemmin, half a mile below Castl comer, a thin bed of coal makes its appearan in a stream, close to the road side. The fi clay and seat rock are very thick, but the strat fication is so much disturbed and broken, th it was impossible to determine with certain whether this bed of coal is, or is not, a contin ation of the first bed of slate coal.

It would be useless as well as endless to d scribe all the places that were fruitlessly ex mined in that part of the circumference of tl circle between Ballyhemmin and Wolf Hill. shall conclude my observations on this bed coal, by stating my full persuasion that it w originally deposited complete within the who circle, though possibly not of equal thickne and quality throughout, but that the undulatio and dislocations that have subsequently take place over the whole coal district, and whic are more than usually numerous to the west the river Deehan, have so far interrupted th continuity of this bed, as to render it impossibl to trace it accurately between Ballyhemmin an Wolf Hill.

If we examine the western extremity of th great section of the district, Plate No. 2. th two beds of coal that occur in the lands of Mo hora, appear in a certain degree to correspon with the first bed of slate coal, and the Ros more foot coal below it, but their characte without further proof are not sufficiently simil to carry conviction as to their identity. Beds similar to those of Moyhora have been discovered at Crut to the north of it; but between this last place and Wolf Hill nothing was discovered except some beds of soft culm, which appear in the ditches to the west of Chatsworth; and owing to the thick clay covering, no section either above or below them could be seen. The first bed of slate coal dips on all sides from the edge toward the interior of the coal district. We may therefore conclude that it extends, without interruption, from one side of the district to the other.

In describing the different situations where the first bed of slate coal has been worked, the Moira colliery was mentioned. This colliery is situated a mile to the south of Wolf Hill, as will appear by referring to the map, and nearly in the direction of the dip of the strata at that colliery. It might therefore be supposed that the coal would be found extremely deep at such a distance to the dip; but this is not the case, owing to its being thrown up nearly to the surface by the sandstone undulation of Drimsallagh Hill, in a manner similar to that represented in section No. 4. This colliery was discovered a few years ago, and three pits were sunk to the coal by the Grand Canal Company, on one of which a steam engine was erected to draw the water; however the colliery was soon abandoned, and the steam engine removed.

The first bed of slate coal is usually composed of three distinct varieties of coal, namely, solid coal which lies at the top, eighteen inches in thickness; culm or soft coal three inches; and kelves or coal mixed with slate fifteen inches, making altogether three feet between roof and floor. The solid part has a tendency to break in rhomboidal forms, and when long exposed to the weather the rhombs divide into flakes from one to three inches in thickness. The fracture of the coal in the direction of the stratification is slaty, but the cross fracture is conchoidal. The solid part of the coal is usually free from sulphur, and when newly raised makes an excellent fire. An average specimen of it was found to be composed of 92 per cent. of pure carbon, and 8 per cent. of ashes.

The coal at Corgee, Paulitien, Ballylihane, and Moira, are nearly similar to the Rushes. It is not so thick at Wolf Hill. At the head of Killeshin glen the solid coal is but twelve inches thick, below it there are three inches of kelve, then seat clay from one foot six inches, to two feet, and afterward eight or nine inches of slaty kelves. The coal at Clogrennan colliery is similar to that at the head of Killeshin glen.

We shall now proceed with the detail of the section.

The second bed of slate coal is covered in the line of the great section, No. 2. and at most of the collieries, by a bed of black slate clay, which is succeeded by slaty sandstone, and this rock by slate clay. In the southern extremity of the Rushes colliery, a bed of grey sandstone ten feet thick lies above the coal, but to the north, this bed gradually disappears. At Paulitien colliery, twenty-three feet above the coal, there is a bed of flinty slate, similar to that which occurs immediately above the limestone already described, which varies in thickness from seven, to twenty feet. But the sections of the alternating strata, that occur in different collieries, will be found under the proper head in the Appendix.*

When this coal is covered by soft black slate clay, the mode of working that I should recommend is that called the *broad way*, which is described in the concluding article of this report. At my suggestion this method has been put in practice with success at Clogrennan colliery.

The system of working that has been adopted at Corgee and the Rushes collieries is represented in Fig. 1. Plate No. 5, in the *Hurrying roads*, which run diagonally across the workings; part of the slate roof is taken down, to make a greater height of head-way. The plan of working, as represented in the plate, has some merit, but no air courses are preserved, and consequently it becomes necessary to sink pits very close to each other; they are rarely more distant than thirty or forty yards. The detail of drawing the coal under ground is similar in this and in all the collieries of the district; and as I shall enter minutely into that subject, when treating of the present mode of working the first bed of three foot coal, I need not enlarge upon it at present.

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* I have carefully collected the journals of the different rocks that have been sunk, or bored through in the numerous trials that have been made of late years, in the Leinster coal district. They are numbered and marked on the map in their proper situations. By this means any future investigator will be enabled to ascertain without any difficulty what trials have been made, and draw his conclusion accordingly. Many of these documents are in the hands of common miners, at whose death they would have been lost, but the greater number were copied from books belonging to Mr. Aher, the manager of the Castlecomer colliery.

SECOND BED OF SLATE COAL, OR TOLLERTON COAL.

The strata which intervene between this bed of coal and the first bed of slate coal, are composed of alternating beds of sandstone, slaty sandstone, and slate clay; as may be seen by referring to the table, or to section No. 2. The coal itself is very similar to the first bed of slate coal, but it is harder, and breaks rather into cubical than rhomboidal fragments: it is also accompanied by kelves or soft slaty coal. The solid coal varies from eighteen to twenty-four inches in thickness, and the soft, from twelve to eighteen inches. Sometimes the upper part of the solid coal has a fibrous texture, and when exposed to the air divides into plates of an inch in thickness; this is called kennel. But this fibrous species rarely exceeds four inches in thickness.

The second bed of slate coal has not been discovered or worked in as many places as the first. The principal collieries are the Tollerton and Ardategle on the east side of the district, and Firoda on the west. This bed of coal is apparently lost to the north of Tollerton, in the valley through which the new Carlow road has been made, in the same manner as the first bed of slate coal; to the south it has been traced for a considerable distance through the colliery of Ardategle. Between this point and the river Deehan, the face of the country is covered to a vast depth by clay, which has prevented the accidental discovery of the outgoings of this coal to the south west of Ardategle, and no trials have ever been made; but there can be no doubt of the existence of the coal in that line. In fact the discovery of the outgoings of the first bed of slate-coal which lies below it may be considered as a sufficient proof.

The undulations and disturbances that have taken place in the strata to the west of Deehan, have been already mentioned, and if we except Firoda, no workable bed of coal appears to exist. Great difficulty arises in proving that the Firoda coal belongs to the second bed of slate coal. If the coal which lies below it belongs to the first bed, the doubt is removed, but it has been already shewn that it is impossible to ascertain this; the coal itself, though similar in thickness, is purer in quality, and not so hard; besides it contains no kelves, but the strata which cover it are similar, and the coal roof in both, is composed of sandstone, excepting where the coal is near the surface, and then it is found to be black slate-clay; but this change also takes place under similar circumstances at Tollerton and Ardategle.

Owing to frequent undulations in the strata, the coal field at Firoda is exceedingly irregular; and the dip of the coal varies so much in direction and steepness, that it is almost impossible to work the colliery with any degree of regularity. In Section No. 5, Plate No. 4, the position of the coal in a north-east and south-west direction is shewn. These frequent changes render the task of discovering the extent of this coal exceedingly difficult. But it is probable that the Firoda coal is very extensive both to to the east and north. In an eastern direction it dips under the town of Castlecomer, and in a northern, having followed the undulations represented in the section, it probably extends towards Crut. The Firoda coal appears to extend considerably to the westward of the present workings, but not to the north. If this were not evident from the coal being worked out to the surface in that direction, the fact would have been incontestably proved by a deep borehole made lately, very unadvisedly, to the north of the outgoing of the coal, and to the rise of the strata.*

In the Tollerton and Ardategle collieries, though considerable workings have been made, and pits innumerable sunk, no coal except that which lies near the surface has been worked; and the best and most solid part still remains untouched: but owing to the accumulation of water it cannot be worked without a steam engine, or by taking up a deep level from the side of the hill.

The undulations in the bed of coal at Firoda colliery, render it more difficult to work to advantage than any bed in the district; but unfortunately at this place less judgment has been displayed than at any other coal work. A very considerable extent of this bed has been wrought, but no profit has been made, owing to the unnecessary number of expensive pits that have been sunk, many of which are twenty-six yards in depth.

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* When first I visited Firoda colliery, this borehole was proceeding in full vigour, and at a very considerable expence. On learning its object it required but little argument to prove to the borers themselves that they were boring beyond the edge of the coal and to the rise of the strata, and consequently were sinking through rocks that lie beneath the coal. In my capacity as a public officer I thought it my duty to inform the agent of the estate (for the Proprietor resides in Engiand) that the boring should be discontinued, as not likely to lead to any beneficial result.

The second bed of slate-coal being very similar in its nature, and similarly circumstanced with the first, the broad method of working would be the most economical that could be applied to it. Indeed the mode that has been practised at Tollerton and Ardategle, though conducted in a slovenly manner, is less to be objected to than perhaps any other in the country. Having drifted on a level on either side from the pit, the colliers work to the rise, seven men abreast, each man occupying three yards, altogether twenty-one yards. But as no air courses are preserved, according to the general custom of the country, pits are sunk very close to each other. See Plan, Plate No. 5, Fig. 2. The practical part of drawing out the coal is exactly similar to that practised in working the first bed of three foot coal, and will there be described.

The second bed of slate coal is generally covered by a bed of grey sandstone 18 feet thick; this is succeeded by a thin bed of coal 2 inches thick; next is a second bed of sandstone which contains fragments of slate clay 36 feet thick, and then slaty sandstone 36 feet; these several strata have been sunk through in the different pits at the Ardategle and Tollerton collieries. Owing to the great thickness of clay covering it was impossible to ascertain with any degree of accuracy the outgoings of the different beds which lie above the slaty sandstone of Tollerton colliery and that met with at the bottom of the borehole No. 26, near Drummagh colliery, an height of 190 feet; the beds that are drawn in the section No. 2, between those points, are not placed there from actual observation on the spot, but from borings made at Mass Ford, and to the west of that colliery, where some of the same beds of coal occur that are met with on the east side of the coal bason. From these data, and also from borings made at Monteen colliery, and to the south of it, I am of opinion that a bed of coal, nine inches in thickness, occurs in the series at the height of 110 feet above the second bed of slate-coal, as marked in the section. This bed of coal has been discovered in many places, particularly to the east of Kilgorey, to the south of Monteen and Ahamucky collieries, at Loon orchard and other places south of Massford.

The next bed of importance in the series is the

FOUR FOOT COAL.

This stratum has now been discovered in six different places. By calculation it appears to be 115 feet above the nine inch coal just mentioned, but its extent or the general line of its outgoing has not yet been fully determined. This bed of coal was first discovered, and three pits were sunk on it at Geneva colliery, in the year 1796 or 1797; it was then supposed to form a part of the first bed of three foot coal, which will be described in its proper place, but which lies at least 240 feet above it. The Geneva colliery was soon abandoned, owing to the great quantity of sulphur pyrites contained in the coal. In the year 1805, the four foot coal was bored to at Kilgorey, by the Grand Canal Company, but no pits were sunk. Their agents supposed it also to belong to the first bed of three foot coal. In the year 1809 it was discovered in the glen of Ahamucky, by Mr. Aher, manager of the Castlecomer colliery, who first observed that it possessed characters essentially different from the first bed of three foot coal, and besides that there was no fire-clay or coal-seat below it. Mr. Aher afterward sunk some pits on this coal at Monteen colliery, and lastly he caused two deep boreholes to be made below the seat-rock of the first bed of three foot coal, and at the depth of 214 feet at borehole No. 20, and 248 feet at borehole No. 21, at Massford he discovered the four foot coal. In these boreholes the coal appears to be thicker and more solid than in any of the other trials. The upper part of the bed is composed of five feet five inches of slaty coal or kelves, under which is three feet of hard coal containing some sulphur pyrites, then a bed of black slate-clay of six inches thick, and lastly one foot of coal containing a thin bed of kelve near the bottom, making altogether a height of coal-kelve and slate of ten feet, of which but four feet are solid coal.

At Ahamucky the thickness of the kelve or slaty coal is but 1 foot 6 inches, which is succeeded by black slate-clay and pyrites, and lastly very hard coal containing some bands of pyrites 3 feet.

At Monteen colliery the thickness of the kelve is 2 feet 4 inches, and of the coal 4 feet. After much consideration and comparison of the strata in the different pits and borings, in which I received great assistance from Mr. Aher, I was enabled to determine with reasonable certainty, that the four foot bed of coal occurs on an average at the depth of 80 yards below the first bed of three foot coal. Owing however to the increasing thickness of some of the sandstone beds, the depth varies considerably, particularly at the top of Coolbane-hill, where a borehole has been made in search of the coal; more than 80 yards have already been bored beneath the three foot coal, and the sandstone bed which in other borings lies above the black slate-clay which forms the roof of the coal, has not yet been penetrated.

From the different positions in which this bed of coal has been discovered, it appears that there exists at least 5000 acres of it in the district, the greater part of which, as it lies beneath the first bed of three foot coal, will be found at the depth of from 100 to 140 yards.

None of the places at which the four foot coal has been discovered, except borehole No. 21, at Massford, happened to be in the line of the great section No. 2, and consequently the position which this bed of coal occupies in the section has been determined by calculating the distance at which it lies, beneath the first bed of three foot coal. It is probable that at the expiration of three or four years the whole of the first bed of three foot coal, which has hitherto supplied the market with hard coal, will be consumed, and if it were not for the discovery of the four foot coal, no resource would have been left, excepting the first and second beds of slate-coal; but the coal of these beds is of such a soft and tender nature that it will not bear long carriage, and therefore could not have answered as a substitute for the present hard Kilkenny coal. The four foot coal is closer in its grain and much harder than the coal hitherto known by the name of Kilkenny coal. Its specific gravity is 1.591. Upon analysis it was found to be composed of 96.25 per cent. of carbon and 3.75 per cent. of dark grey ashes. Owing to its great depth this bed of coal must be worked according to a regular and scientific plan. The narrow way of working, as represented in the plate at the conclusion of this report, is the best that can be followed, and by this means one pit will be sufficient for an extensive colliery, and the increased depth of the coal will be of no material consequence. I have already mentioned that this bed of coal is composed of a stratum of slaty-coal or kelve at the top, then a bed of black soft slate, and lastly four feet of solid hard coal; at least this is the general arrangement. The plan of breaking down the coal, which I should recommend, is to commence by working out the bed of soft slate and throwing it aside, next to wedge down the kelve, and lastly to wedge out the solid coal. By this plan it will not be requisite to cut the solid coal, excepting at the sides next the pillars. This is material, as owing to its extreme hardness, the holeing in the coal, either at the bottom or top, would be a most tedious and expensive operation.

The kelve or slaty-coal will answer extremely well for burning lime, and the solid coal, when properly separated from the bands of sulphur, pyrites will be found nearly equal in quality to the hard coal at present sold. The bands of pyrites need not however be rejected as useless, for by proper management they may, at a trifling expense, be converted into sulphat of iron, (the common copperas of commerce.)

The four foot coal is covered by alternations of black slate-clay and clay-ironstone, forming a succession of beds of 15 feet. They are succeeded by beds of sandstone and slaty sandstone, in which there is nothing remarkable; indeed the only bed worth mentioning which occurs in the strata immediately above the four foot coal is a hard siliceous stratum three feet in thickness. The colour of the rock is dark smoke grey; its lustre is dull, and fracture earthy. It contains numerous calcareous impressions of muscle shells, but the calcareous matter is confined to the shells alone, none being contained in the mass of the rock. This bed occurs generally at the height of 34 yards above the coal.

THE FIFTH BED OF COAL; OR THE FOOT COAL,

No. 85.

This bed of coal is usually met with 40 yards above the four foot coal, and also 40 yards under the first bed of three foot coal. It varies in thickness from eight inches to one foot. It occurs only in the centre of the mineral bason, where the covering of clay on an average is 36 feet thick. On this account its outgoing has been discovered in very few places, but the coal has been sunk and bored to in more than one hundred places. These borings and sinkings were not however made in search of it, but generally in expectation of finding the first bed of three foot coal. A great number of these borings are marked on the map, and the proximity of many of them to the outgoing of the three foot coal is remarkable. This bed was attempted to be worked many years ago at Drummagh, where it occurs near the surface, but nothing worth mentioning was accomplished.

There is nothing remarkable in the strata which intervene between the Drummagh foot coal, and the fire or seat-clay, beneath the first bed of three foot coal. This bed of fire clay is of very fine quality, and is in my opinion superior to that of Stour-Bridge in Worcestershire, already mentioned. Excellent fire bricks have been made with it, but no manufacture to any extent has been attempted.

According to Mr. Tighe, this substance is composed of 54 per cent. of silex and 44 of argill,* but from my own experiments, the ingredients and their proportions vary in different beds.

THE SIXTH BED OF COAL, OR THE FIRST BED OF THREE FOOT COAL.

This bed of coal is of excellent quality, and is infinitely superior to any other that has been discovered in the district. It is generally known by the name of the Kilkenny coal. It was analysed with great care by Kirwan. According to him it contains from 96 to 97 per cent. of pure carbon, and from 3 to 4 per cent. of ashes. It is much purer than the carbonaceous coal of South Wales and Scotland. The specific gravity of this coal is 1.526; it is greater than that of any bituminous coal. On this account a horseload of it occupies a smaller compass, but owing to the closeness of its grain, it consumes so slowly that one ton of it will give out more heat, and last much longer than the same weight of any other species of coal. It is extremely hard, and may be carried a great distance over rough roads without breaking in the least. This bed of coal varies in thickness from 2 feet 6 inches to 3 feet 4 inches. The roof, as appears by the section, is composed of black slate-clay, which varies in quality in different places. It is however generally tender, and may be considered on the whole as a bad roof.

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* Statistical Survey of the County of Kilkenny, p. 58.

The first bed of three foot coal lies 80 yards above the four foot, or newly discovered coal; it has long been considered as the only one of importance in the coal district. Its extent, in comparison with the preceding beds, is very trifling. It lies very irregularly, being formed in small basons, filling up the vallies between the hills; its boundaries were accurately traced with great facility, as unfortunately the greater part of this most valuable bed has been wrought out. The irregular outline of the different basons in which this bed of coal has been found, need not here be described, as they are all traced on the map. The first bed of three foot coal extends irregularly through part of three great royalties, viz. The royalties of the lordship of Castlecomer and Clogh, which are situated in the county of Kilkenny, and the Doonane royalty in the Queen's County. In these three royalties, three great collieries have been worked; but the most important, and by much the most extensive is the lordship of Castlecomer colliery. This colliery was commenced in the beginning of the last century, by Sir Christopher Wandesford, and has continued at work, almost uninterruptedly, ever since. The first workings were made on the top of Coolbane-hill, where the coal lay near the surface; but afterwards workings were commenced at the base of the hill, where the coal having been thrown down by a slip of 70 yards, as represented in section No. 3. In different situations along the flat at the base of the hill, the colliery has been continued working until the present time. In this royalty from 15 to 20 acres of coal, situated at Massford, two miles above Castlecomer, and a few acres on either side of the Castlecomer road, are the whole that remain unwrought, out of an extent of nearly 3000 acres. This bed of coal has also been worked to a considerable extent in the Doonane royalty, but the old colliery of Doonane has been abandoned since the year 1798. Subsequently, in the year 1803, the Grand Canal Company, (the present lessees of the royalty) discovered a detached bason of the coal on the lands of Boulavoneen, in extent about 60 acres. This colliery has now been at work seven years, and has lately become very profitable.

In the royalty of Clogh the first bed of three foot coal was discovered many years ago; a steam engine was erected to drain it, and many pits were sunk, but the colliery was soon afterwards abandoned, it is said owing to the badness of the roof.

The system of working that has been followed at these several collieries, is perhaps the most improper and expensive that could have been adopted. The appearance of the surface in every part where the coal has been wrought, bears a strong resemblance to a rabbet warren; there being a continued succession of hillocks and holes. Indeed the number of pits that have been sunk may justly be compared to the perforations in a cullender. It is not wonderful, when the colliery was first commenced by Sir Christopher Wandesford, that the coal was only wrought where it was shallow, and that ignorant colliers found it less troublesome to sink pits every 20 or 30 yards than to support a bad slaty roof, and extend the works farther. But it is to be regretted that in these times, when in England the art of coal working and mining machinery have been brought to the greatest perfection, that the Kilkenny colleries should have continued without any improvement in the underground workings, for the last hundred years, as the very same system pursued by Sir Christopher Wandesford in the commencement is still persisted in; for even where the coal is 60 or 70 yards deep, the pits are rarely more than 100 yards asunder, and this is quite necessary according to the present slovenly system of carrying on the underground workings. No regular air-courses being preserved, the workings cannot be extended to any considerable distance from the pit, and consequently whereever the air is deficient, a new pit must be sunk.

It would have been extremely difficult, within the last ten years, to have made any material improvement in the mode of working in the colliery of the lordship of Castlecomer, as there were frequently 15 or 20 pits at work, some of which were three miles asunder. This colliery has, during the last 50 years, been managed by a number of successive Irish and English agents, without any improvement being made. The present manager, Mr. Aher, is an Irish gentleman, and a very scientific man. He found it impossible, from the circumstances above stated, to attempt any alteration of the system. Before he was appointed to the management, the colliery was considered as worked out, and the new workings made by him have, for the most part, been on detached patches of coal that were left or forgotten by former managers, and some trifling basons of coal which he discovered. Mr. Aher is certainly the only person in the country who understands, or has studied its stratification, and I am indebted t him for the details of the numerous borings made in the Castlecomer royalty, which amongst others will be found in the appendix; and als for his assistance in affording me materials fo the east and west section of the Castlecome colliery, plate No. 4.

In order to convey my ideas of the improvements that may be made in working these collieries, it is necessary that I should first describ the system that is followed at present. For th plan of working, I beg to refer to plate No. fig. 3. The pits are there represented as bein sunk at the distance of 80 yards; they are su ported by four pillars of coal, each six yar square. The first operation is the cutting passage or air course between the pits; this i called splitting. The general working on th coal is next commenced, and followed on according to the system represented in the plan the parts left white are the *rooms* or *board* which are first excavated; their dimensions ar 15 feet long by six broad: between each of th *boards* a pillar of coal six feet by three is left t support the roof; in the centre between the pi a barrier of coal is left as a further support to th roof; when the whole extent to the rise whic the pit can command, has been wrought as represented in the plate, as many of the pillars are cut away as can be removed with safety; but it rarely happens that more than one-third are saved.

When a pit is sunk and ready for work, the agent generally lets it to a *master collier*, who is a species of middle man, between the collier and the agent. The master collier agrees to deliver the coal on the surface for a certain stipulated price, which varies from 6 to 8 shillings a ton, according to the difficulty of the work. This man engages a number of collier's or a *crew*, as they are generally called, to work with him; each man has a particular kind of work allotted to him, and a certain portion is considered as a day's work; a *crew* consists frequently of 50 or 51 persons, who are divided into

	£.	s.	d.
20 Clearers, whose wages per day is 2*s.* 2*d.* each	2	3	4
20 Cutters, ditto	2	3	4
6 Breakers, ditto	0	13	0
2 Hurriers, ditto	0	4	4
3 Thrusters, 1*s.* 8*d.* each	0	5	0
Total cost of labour under ground for one day	£5	9	0

The work is commenced by the *clearers*, who clear away the slate from the top of the coal generally for one yard inward, but that depend on the distance of the next back or natural division in the coal; when the clearer meets on of these, he always stops. The clearer's tas is to clear the slate from the top of the coal fo a length of from two yards and a half to thre yards; he is succeeded by the cutter, whos business is to make a cut or incision in the co from *roof* to *floor* either a yard inward or t the next *back;* the cutter makes seven cuts fo his day's work: last comes the *breaker*, wh breaks down the coal by wedges generally dr ven in at the bottom. When broken down, th coal is put into a wooden box, which holds a hundred weight, placed on a small sledge, an is drawn by the *hurrier* to the pit bottom by means of an iron bar hooked into a ring on th front of the sledge. The *thruster* pushes th box behind. Besides the expense of the labou of the *crew*, the master collier finds horses t raise the coal from the pit bottom to the surface, by means of a horse-gin, and also candle for the use of the workmen under ground.

Objections may be made to this mode o working in almost every stage. The first is th immense sums which the proprietor pays fo sinking so many pits, and the consequent expense of watchmen at each pit, to prevent pillage, which even with this precaution is stil very great. Secondly, The master collier pay the collier hurriers and thrusters by the day, no by the quantity wrought, and owing to the slovenly manner in which the coal is worked, the difficulty of dragging it through the passages is so great, that the hurrier and the thruster necessarily receive a greater part of the money than should come to their share if greater regularity were preserved.

In the concluding part of this report, a description of the mode of working collieries on the most improved plan will be found. I need therefore only observe in this place, that the system of working, by master colliers, should be discontinued; that each collier should work for himself; that hurriers should be paid by the ton for drawing the coals to the pit bottom, and should be independant of the collier; that the boards or drifts in the coal should be laid out by the manager, on a regular system, not according to the whim or judgment of the collier; that air-courses should be regularly preserved throughout the workings, which by this means might be much more extensive in each pit than they are at present; that rail-ways should be laid in all the great leading passages throughout the work, and that the hurriers should draw the coals to the pit bottom, in waggons. By this means the thrusters might be discontinued, and in deep and extensive pits the roof should be taken down in the leading passages of the mine, and horses employed instead of men underground, to draw the coals to the pit bottom, according to the manner described in the concluding article of this report.

I have no doubt that Mr. Aher would have encountered the Herculean labour of attempting to remove the prejudice of the colliers, and have worked Massford colliery on an improved plan, had not all the pits which are requisite to work the colliery according to the old system been sunk long since by a former manager.

I cannot help regretting that the Grand Canal Company should have commenced, and persisted in following the wretched system of the country, in their colliery on the lands of Boulavoneen, now called Newtown. This coal varies from 3 feet to 3 feet 4 inches in thickness, and is solid from top to bottom. The engine pit is 68 yards deep, and the shallow pits, to the rise, are from 25 to 30 yards. (See east and west section of the district.)

This colliery, which originally consisted of about 60 acres of the best coal ever discovered in the Leinster district, has now been working seven years, and many pits have been sunk and wrought out, in which, as is usual, half the pillars have been left behind. Had this colliery been properly commenced, the whole of it might have been worked from the engine pit, enlarged to twice its present dimensions, and divided into three compartments, through two of which coals might have been raised by a winding steam engine, and the water through the third. There are several much more extensive collieries at Newcastle on Tyne, worked advantageously from one pit, where the coal is nearly at the same depth below the surface as at Newtown, namely between 60 and 70 yards. But at Newcastle horses are used under ground to draw the coals to the pit bottom.

Had this system been originally adopted, the quantity of coals raised per acre would have been much greater than at present. The expence of sinking the numerous pits, the erection of horse gins, and all the apparatus belonging to a pit, would have been saved, as also the whole of the horses at present employed at the different pits to raise the coal. Pillage would have been completely prevented by an enclosed yard round the pit, and instead of the present requisite number of watchmen, one would have been sufficient. It would be endless to enter into any further detail of the savings that would have attended the adoption of the improved mode of working. I shall conclude by recommending strongly to the Grand Canal Company still to exert themselves to change the present wretched system, and if they attempt nothing else, at least a proper plan of ventilation might without risque be adopted, so as to prevent the necessity of sinking any new pits, many of which, on account of the depth, would be very expensive.*

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* The Newtown colliery was for many years very unproductive, notwithstanding the enormous price of twenty shil-

The strata which rest upon the first bed of three foot coal are, first,—black slate clay, containing numerous balls of clay ironstone, usually arranged in beds of one inch in thickness. This bed varies in different places from three to twelve yards in thickness; it is succeeded by a bed of slaty sandstone, which on an average is five yards thick, above which is grey sandstone ten yards, then blue arenaceous slate-clay twelve yards. This bed is followed by the coal seat of the double seam.

SIXTH BED OF COAL, OR DOUBLE SEAM.

This bed, which is situated from forty to forty-five yards above the first bed of three foot coal, consists of two beds of coal separated by a bed of seat or fire-clay, which varies in thickness from six to eighteen inches; the upper bed of the coal is usually ten inches, and the lower twelve inches. Its occurrence in the district is very rare; it has never been met with except to the west of the great down throw, in

lings a ton being paid for coal at the pit mouth: but within these last two years, Mr. Ross, the present manager, has by regularity and perseverance, changed the face of things, and rendered it very productive, though the country system of working is still persisted in to its full extent.

the Lordship of Castlecomer colliery, on the side of Coolbane hill, as represented in section No. 3, and immediately below the clay covering, at the engine pit of Newtown colliery. Its extent on Coolbane hill is very trifling. It only occurs between the two slips, represented in section No. 3. This bed has never been worked. It is covered by a bed of black slate-clay, which contains beautiful impressions of ferns, it is succeeded by the coal seat of the

SECOND OR UPPERMOST BED OF THREE FOOT COAL.

It lies seven yards above the double seam. Its quality is very inferior to the first bed of three foot coal. It has not been met with in the district except between the two slips in Coolbane hill, already mentioned. Its extent is nearly equal to that of the double seam. This bed of coal, which is the uppermost in the district, is covered by a bed of black slate-clay interstratified with beds of clay ironstone, usually one inch in thickness; these alternations continue to the surface, and form the uppermost strata of the coal district.

Thus it appears that there are eight beds of coal in the principal division of the Leinster coal district, which rest one upon the other in regular succession, namely,

1. The Rossmore foot coal.
2. The first bed of slate-coal.
3. The second bed of slate-coal.
4. The four foot coal.
5. The second foot coal, or Drummagh coal.
6. The first three foot coal.
7. The double seam.
8. The second three foot coal.

We shall now proceed to the consideration of the detached beds of coal.

DETACHED BEDS OF COAL.

In the foregoing pages the principal object has been to describe the general stratification, and the outgoings of the several beds of coal that occur in the great mineral bason which occupies the northern division of the Leinster coal district. The situation of some thin beds of coal, apparently unconnected with the others, still remain to be described.

In the lands of Rockbrook, to the south of Gaulstown, there is a thin bed of coal, on which some workings were formerly made.—The stratification is extremely regular in the valley of Rockbrook, and if the field of coal should prove extensive, it may be wrought to advantage. Owing to the great thickness of alluvial matter which conceals the strata, no traces of the coal could be seen, except very indistinctly in two places. But from the appearance of the seat rock, and the general regularity of the stratification, this valley seems to merit a trial. The coal is apparently of a slaty nature, and may possibly be a continuation of the first or second bed of slate coal. Many trifling indications of coal have been observed south of Rockbrook, particularly near St. John's well, and at Ballygurteen, but the stratification undulates exceedingly, and the coal is rarely more than from four to six inches in thickness. To the west of Firoda, an irregular and undulating bed of slate-coal has been exposed to view in the channels of the mountain streams, particularly at Lowhill, and in that neighbourhood. A pit was formerly sunk on this bed to the north of Lowhill, and the usual tradition of a thick bed of good coal having been found, (though through bribery the pit was immediately closed up,) induced some persons to re-open it, some years ago, at a very considerable expence. When they arrived at the bottom, the bed was found to be composed of eight or ten inches of soft slate-coal. This pit was originally sunk in the centre of a steep and narrow undulation of the strata; for the same bed of coal, which is thirty yards deep where the pit was sunk, appears at the surface sixty yards to the west of it.

In the Cullenagh hills, which form the north western extremity of the district, four beds of slate-coal mixed with slate-clay have been discovered, but they are all thin, and even if they were of sufficient thickness, they could not be worked; for the strata on all sides dip into the hill at so steep an angle (frequently of 30° and even of 45° from the horizon) as to render it impossible to follow them for any distance, owing to the rapid increase in the thickness of the cover. Many trials have been made at different periods in all these beds; and some of the old pits were lately re-opened on the estates of Lord Norbury and Lord Tara, on Lord Norbury's property. At the depth of fourteen yards, a bed of coal mixed with slate and slaty coal one foot thick, was found, but there was only two inches of solid coal. An ancient borehole, carefully stopped at the top, was also discovered; it is said to be forty yards deep, and the old men assert that a *thick* bed of coal was found at the bottom: however from observations on the alternation of the rocks, below the first bed of coal in a neighbouring stream for more than forty yards, I can venture to contradict the report. The strata are so irregular and changeable, that a *thin* bed of coal might possibly have been found in the borehole, which either did not appear in the stream, or from its insignificance was passed over. But it may be safely asserted that no bed of coal, even of one foot in thickness, exists there.

Two very impure and irregular beds of slaty coal were found on Lord Tara's estate, one of which varies from six to eighteen inches in thickness. Some trial pits have formerly been made on these beds, one of which has lately been cleared out, but nothing worth following was found. These discoveries and trials have all been made on the south side of the hills. In the stream to the north nothing was visible except the remains of some old workings for ironstone, which appear to have been very extensive. The ironstone was conveyed from Cullenagh to the iron works at Mountrath to be smelted.

Some years ago a trial was made at Blandsfort to the east of the Cullenagh hills, but without success; and from what I have seen of the stratification of the country, it is very unlikely that any workable bed of coal exists in the valley to the south of those hills.

OF FRUITLESS TRIALS FOR COAL.

During the last twelve years more than 200 pits and boreholes have been sunk in the royalty of Castlecomer, and by the Grand Canal Company in the royalty of Doonane. Very many of these have proved fruitless, and some have been made in situations where a little experience and some knowledge of the stratification of the country, would have been sufficient to have proved that no coal existed. Though many of the trials made by the proprietors of the Lordship colliery have likewise proved fruitless, they were all undertaken with a view to ascertain the extent of some particular bed of coal, in situations where the clay covering prevented any satisfactory observations being made on the stratification at the surface. The inconsiderate trials were made under the direction of a succession of English and Scotch coal viewers and agents, at the expence of the Grand Canal Company, who thus threw away many thousand pounds in sinking and boring for coal, beyond the outgoing of the first bed of slate coal, that is, through the strata which lie beneath it. Had Killeshin glen, or any of the other numerous deep cuts on the eastern face of the colliery hills between Corgee and Killeshin been carefully examined, it would have been discovered that no workable bed of coal exists in the first 860 feet above the limestone, and consequently the pit at Spring Hill never would have been sunk through black slate into the limestone, or the trial near Ballickmoyler at the edge of the limestone would never have been commenced.

Many fruitless trials for coal have been made in the days of ignorance by country gentlemen and farmers, in the strata beyond the outgoing of the lowest workable bed of coal; but within these twelve years none have been attempted, excepting by the Grand Canal Company.

To enter into the detail of the erroneous and expensive system they have pursued, though it might prove a warning to future mining companies, would lead to a discussion of too great length. It is to be hoped, however, from what has been said, that no trial will in future be made beyond the edge of the lowest workable coal in the Leinster coal district.

The quantity of coal annually raised in the principal division of the Leinster coal district may be on an average about 70,000 tons of hard coal, and about 100,000 of soft coal or culm. The whole of the hard coal is raised from the Castlecomer and Newtown collieries, but in addition to them, culm is raised at the Firoda, Tollerton, Wolf Hill, and Clogrennan collieries, which increases the quantity of culm raised.

The price of coal at the pit mouth is twenty shillings a ton, and of culm about five shillings; but the price of culm varies according to the proximity of the collieries to the markets, from five to eight shillings a ton. The culm of the great collieries is composed of the hard coal broken small in the operation of working; but the culm of the thin beds is, as I have already mentioned, naturally a soft slaty coal, which quickly divides into thin plates by exposure to the air, though it may have been brought up from the pit in large thick flakes. The principal markets for stone coal are Kilkenny, Carlow, and Athy. That brought to Kilkenny and Carlow is used in those towns, and their immediate neighbourhoods. The coal brought to Athy is chiefly sent by the Grand Canal to Dublin, Tullamore, and even by the river Shannon to Limerick. In distant places the coal is used only for malting, for which purpose it is peculiarly adapted, as it neither flames nor smokes. Stone coal is also shipped at Leighlinbridge on the river Barrow, for the supply of the Ross and Waterford markets. The culm or soft coal of the Leinster coal district is chiefly used for burning lime, and for this purpose it is sent for by the farmers of all the surrounding counties, but particularly from the mountainous district of the counties of Wicklow and Wexford.

The coal of the first bed of three foot coal is by much the purest in the district. It has been used at the collieries to melt iron in cupola furnaces. Cast iron of the best quality might be made with this coal, if it could be raised at a sufficiently low rate; but at the present price of twenty shillings a ton it could not answer. On this account I have dwelt less than I should otherwise have done, on the number, quality, and thickness of the different beds of clay ironstone, which occur between each of the beds of coal, and also in other parts of the district where no coal exists.

Stone coal is peculiarly adapted to culinary purposes. When once perfectly ignited it will burn without any apparent alteration for many hours, but it is certainly less agreeable for general domestic purposes than bituminous or blazing coal. Owing to the high price of hard coal, and scarcity of turf, many of the peasants of the county of Kilkenny and Queen's county make an excellent substitute, by mixing pounded culm with one-fourth part of clay; unctuous or friable mould answers much better than stiff clay, and probably bog-stuff will be found superior to either. The culm and clay are worked together like mortar, and then formed by the hand into balls of about three inches diameter. These balls are made use of instead of coal, and are put on the fire wet; when once ignited, they burn extremely well, and make a more agreeable and lively fire than the hard coal. The increased liveliness may be attributed to the balls being rendered porous from the shrinking of the clay by heat, the air (by this means) getting admission to the different sides of the small coal; whilst in the hard coal, the body is so compact, that nothing but the exterior surface is exposed. When a fire made of balls is well lit, it may be slacked down by a cake of the mixture of culm and clay being laid wet on the top in a similar manner to bituminous coal.

OF MINERAL WATERS.

The chalybeate species is the only kind of mineral waters which occur in the Leinster coal district. The springs most frequented for their medicinal virtues are those of Castlecomer and Ballyspellan, neither of which are very strong. The waters which issue from the levels of the different collieries, and from some old boreholes, are much more strongly impregnated with sulphat of iron than they are. But the spa at Ballyspellan contains carbonic acid gas, in addition to the sulphat of iron.

OF ROADS AND CANALS.

The great leading roads from the collieries to the principal markets are generally kept in good repair, but the bye roads are execrable indeed. Many of them serve for the double purpose of a road and a river. The road from Castlecomer to Kilkenny is on the whole well laid out, but that from Castlecomer to Athy has been laid out over hill and dale, nearly in a straight line between the two places. A more level line of road might easily be formed, so as to avoid the hill of Doonane, Drimsallagh, and especially the summit of Corgee hill, but it is to be feared that the great expense will for many years delay the completion of a new road in that direction. Within the last six years, a new road has been made between the collieries and Carlow. It was laid out with consummate skill and judgment by Mr. Aher, the manager of the Lordship of Castlecomer colliery. The chief part of the expence in making the road was raised by subscription in the country.*

A very practicable line of canal was laid out by Mr. Sparks, from the Grand Canal to the town of Castlecomer. This canal was at one period a favourite object with many gentlemen of the Queen's county, but at present it appears to be forgotten. This line, together with one laid out by Mr. Kilally, between the Grand Canal at Athy and the Nore above Kilkenny, are marked on my map of the coal district.

OF THE DIFFERENT METHODS OF WORKING COAL.

The collieries that have been wrought, and are at present at work in the Leinster coal district, have been, and are conducted in a faulty and expensive manner, in almost every department. With a view to point out the errors more clearly, and, if possible, to improve the present system, I shall give a short outline of the different approved methods of working coal, and describe the situations to which those different methods are applicable.

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* The Dowager Countess of Ormonde subscribed £1000. towards this road. I am happy in having this opportunity of expressing my admiration of the liberal manner in which that lady at all times supports every project which may tend to the benefit of the country. To make her neighbours and tenants comfortable and happy, and to improve the surrounding country by every means in her power, appear the noble and patriotic boundary of Lady Ormonde's wishes and exertions.

In the commencement of any coal work, the first object of attention should be to free the field of coal from water. This may be effected by a level, if the situation permits it; or by sinking a pit on the lowest point to the dip of the field of coal, so that all the water of the colliery may be conducted to the pit bottom, and thence raised to the surface by pumping engines, moved by steam, water, wind, or any power or means that is found most convenient. If the engine or water pit be in an improper situation, which is by no means an uncommon occurrence, the proprietor will necessarily be put to the expence of sinking a new pit, to unwater that part of the colliery which the first could not command, or sink the pit deeper, and drive a level in the under strata so as to meet the coal to the dip of the engine pit. Too much care cannot therefore be taken, previous to sinking an engine pit, to ascertain with accuracy the direction of the dip, and the angle of inclination which the coal or upper strata makes with the horizon. The upper strata are mentioned, as they are usually parallel to the coal;

and consequently if the direction of their dip and inclination can be taken at two or three places at the surface, and are found to agree, the engine pit may be sunk with confidence from the knowledge thus acquired.

This being effected, the next object of consideration is the mode of working which is suited to the particular bed of coal; this will be determined by the thickness of the bed, its depth from the surface, and the nature of the roof or rocky bed which covers it, and also of the floor, or rock which lies beneath.

There are two distinct methods of working coal; the *narow* and the *long* or *broad* way; the narrow way is commenced by cutting passages through the coal, both length ways and across, leaving rectangular pillars between the passages. By the first operation one-third of the coal is generally taken out. But when found convenient, the pillars which remain are afterwards removed, commencing with the most distant, and ending with those next the pit. By the broad way, the coal is wrought out at once, frequently for a length of 150 yards in one face, without leaving any pillars of coal to support the roof. The former mode of working is adapted to beds of coal which occur a considerable depth beneath the surface, from 50 to 100 fathoms; and which have a strong roof either of sandstone or slaty-sandstone. The broad method is adapted to beds which lie nearer to the surface, and which are covered by a tender roof of slate-clay, which falls quickly after the coal is removed.

OF THE NARROW METHOD OF WORKING COAL.

Most of the great and deep collieries in England are, with trifling variations, arising from various local circumstances, worked according to this plan. In taking a general view of the whole, I am inclined to give the preference to the improved system at present adopted at the collieries of Newcastle upon Tyne; and which, with trifling modifications, might be followed in any colliery.

This improved system has within the last eight years been brought to its present state of perfection, through the ability and unremitting exertions of Mr. Buddle, of Newcastle; and I have infinite satisfaction in having this opportunity of returning him thanks for the liberal manner in which he gave me information respecting his various improvements. According to Mr. Buddle's plan, from seven-eighths to nine-tenths of the coal is at present raised, whilst eight years ago but one half, and frequently less, was all that could be obtained, and therefore through his exertions, the coal owners of the north of England may be said to have encreased their property, at least one-third, as more coal than is equal to that proportion is now raised out of the same area, than could be effected according to the old system.

But Mr. Buddle's talents have not been confined solely to the improvement of working coal; he has also introduced a more perfect system of ventilation, and has put in practice many simple, but excellent contrivances, not only to prevent the accumulation of inflammable air in any part, but also by using hanging doors, which yield to the blast of inflammable air, and are not carried away; he prevents a general explosion throughout the mine when any cavity containing inflammable air is broken into accidentally as the works extend;—by this means, when the first blast is over, the general ventillation of the mine goes on as before, and the lives of the colliers and horses in the distant parts are preserved. None of our Irish collieries contain much inflammable air. I shall not at present therefore enter into any detail on this point, but shall confine my views to the different methods of working and supplying fresh air to the most distant parts of an extensive colliery, by one or more pits.

This knowledge will best be communicated by explaining the plate No. 6, which represents the plan of the improved system of working and ventillating collieries at Newcastle upon Tyne.

The circle below the letter A, is intended to represent a pit or shaft, divided from top to bottom by a boarded partition nicely jointed, so as to prevent the communication of air from one side of the pit to the other. Through the right hand division of this pit, which is called the *downcast*, the air descends; having passed through all the excavations that have been made through the mine, which are represented by the white or uncoloured divisions, it passes up the left hand division of the pit. To aid the draught of air, a great fire is made in a furnace at B, which rarefies the air, and causes it to ascend more quickly through the *upcast* pit or division. The arrows point out the direction of the course of the air, throughout the mine, and the red marks are walls or stoppings, built to force the passage of the air in particular directions. The parts in the plate coloured black, represent the unwrought part of the coal.

The principal advantage of the new mode of working is, that it divides the mine into any convenient number of districts, each of which is to be wrought out in its turn, and the roof suffered to close in. But to prevent the crush created by the falling in of the roof in one part, from communicating with, and injuring the coal in another, a great protecting wall or pillar of coal is left between each division. By examining the plate No. 6, the several divisions or districts may be easily traced by observing the line of large pillars. The first operation of working the coal is represented clearly in the district F. From the bottom [illegible] of the pit, two parallel passages are cut three yards broad and twelve yards asunder; at convenient distances cross cut passages or headings are driven to connect the parallel passages, and thereby create a complete circulation or current of air.

The parallel passages are then continued until air again becomes deficient; a second heading is then cut, and the first is carefully closed up, so as to force the air round the lengthened circuit. This process is continued uninterruptedly around the district as represented on the plate. The district being thus surrounded, broad passages called *boards* or *rooms* are then commenced at the lower end of the district, and are cut at regular distances upward, towards the parallel passages first described. The breadth of the boards and that of the pillars of coal left between them, is continually varied according to the nature of the strata which forms the roof and floor of the coal. The usual breadth at Newcastle is 12 feet for the boards, and 6 feet for the headings, leaving a pillar of 60 feet by 33 between them. In the district F, the boards are represented in progress; this is also the case in the district K;—when the boards and headings have been made throughout a whole district, as is represented in the districts G and H, the next operation is to remove all the pillars; those at the furthest extremity of the district are first cut out; this operation is performed either by commencing at one end, and proceeding regularly to the other, or by cutting the pillar in the middle, and setting a number of men to work at it. But this must depend on the strength of the roof. A few of the pillars of the district G are represented as being removed, and the whole of the coal that could be carried away is represented as being wrought out of district I, nothing except the trifling quantity shewn by the black lines, being left behind. When the pillars of the district G have been wrought out nearly to the boundary pillar between the districts I and G, the boundaries should be divided by boards and headways, and a considerable portion of them may thus be removed.

Owing to the frequent mistakes of sinking pits in improper situations, the pit A is placed in a position with respect to the colliery, that is frequently seen in practice, namely a great part of the coal field lying to the dip, or under the natural water level of the pit. By observing the direction of the dip and rise, as represented on the plan by the great arrow, it is evident that without some contrivance no coal could be level or water free below a line drawn across the pit A, at right angles to the arrow, and consequently half the coal of the districts F and G, and the whole of the district K, must have been left behind. To overcome this evil, the pit A is supposed to be sunk below the coal to a depth more than equal to the level of the coal at M, and a drift or passage is supposed to be horizontally cut through the strata beneath the bed of coal till it meets the coal at M, by this means the district K may be freed from water. Had the pit been originally sunk nearer to M, all the expence and trouble of driving the stone drift would have been avoided.

It frequently happens that the stoppages, or walls built to direct the ventillation, interrupt the communication from the various parts where the coal is working to the pit bottom. When this happens, a door should be placed at a convenient distance on either side of the wall which may then be removed, and the leader of the coal waggons, as he passes along, opens the first door, and having led his waggons past, shuts it, and then opens the second door; by this means the regular ventillation of the mine is constantly preserved.

According to the plan just described, very extensive collieries are worked from one pit, at Newcastle on Tyne, and passages or boards, amounting in the aggregate to 30 miles in length, are perfectly ventillated by a single pit.

The mode of passing the air through the different passages or boards, varies according to circumstances; when a very quick current is required, the air is passed up one board and down the next; or as represented in the plan, or up two boards and down two, or up three and down three. But in small collieries, or where no inflammable air is met with, the passage of air round the boundaries of a district, as that of F, leaving all the ends of the passages or boards open for the air to circulate, it is found sufficient. At the great collieries at Newcastle, the ventillation consists of a current of air of 36 square feet, moving with a velocity of 3 feet in a second.

The different modes of removing the pillars according to circumstances, are represented in plate No. 7 a a, CC, D and e are the different modes of working pillars where it is necessary to preserve the air courses. The pillars are wrought in the manner represented at b b, where the outer parts are much damaged and cracked by the pressure of the roof and floor. And f f when the roof is not sufficiently strong to remain up while the whole pillar is removing. In this case the centre part is left, and both ends are carried away.

The consequence of working the boards too wide is represented in the elevation in the bottom of plate No. 7. The pillars on either side of the board g are represented as much broken both at top and bottom, by the pressure of the roof and floor, and the coal is rendered useless. Besides the passage through the board is nearly closed by the approach of the roof and floor towards each other. The board H represents the appearance in elevation of one that is driven of a proper width. In this case the coal on both sides is solid, and the roof and floor remain in their original positions. In working all collieries, it is better to drive the boards too narrow than too broad; in the first case when the pillars are to be removed, the roof and the coal are both sound, and the whole of it may with safety be removed; but in the latter the centre of the pillars, as represented by b b in the plate, can alone be taken away. When two pits are sunk in the same colliery, the air is carried down one pit, and having traversed the colliery, passes up the other.

BROAD METHOD OF WORKING COAL.

Many of the shallow and thin beds of coal in Yorkshire are worked in the broad way, but the breadth of the banks vary in almost every colliery, from certain local circumstances. I shall describe one, the principles of which may be applied to any shallow colliery, and the proper breadth of the banks, which depend on the nature of the roof, will be determined better by practice than precept.

Plate No. 8 represents a very simple and excellent method of working in the broad way. A is the shaft divided into two equal parts, in the manner already described. B B B are double drifts, with proper headings for air. C C and D D are banks, each 50 yards broad. The dotted marks represent three rows of wooden pillars which support the roof. The light shade represents the parts already worked out where the roof has fallen.

The first operation in the work is to drive the several double drifts. Those on either side of the pit must be completed to the full extent before any other workings can go on. The three double drifts at right angles to the first may then be commenced, and having proceeded 20 or 30 yards, the great working or bank may be commenced, by breaking down the coal along the lines E E upwards. The coals are drawn out through any convenient headway to the pit bottom. Having broken down the coal across the whole bank for three yards to the rise, a row of wooden pillars should be placed from a yard to a yard and a half, to the rise of the coal pillar of the drift; and again, when four or five yards of coal have been wrought, two successive rows of wooden pillars should be placed to support the roof; when six yards of coal have been worked out of the bank, the hinder row of pillars may be removed, and placed in the front, and the roof suffered to fall down in the place the pillars stood. If the roof does not soon fall, it must be struck with picks and hammers, to bring it down, as there is danger in suffering too much weight to press upon the wooden pillars.

In the plate, the banks to the right and left are represented as having made considerable progress. The coals are drawn from the face of the banks on both sides through the openings or headways, by which the air is introduced, as represented by the arrows. I and F are double doors to prevent the air from the left bank returning directly to the pit; by this means it is forced along the face of the workings in the right bank. The first banks being proceeded on to a certain distance, a third and fourth may be commenced to the right and left, and others may be wrought to the rise by connecting the rise drifts by cross ones at right angles to them, and working upwards from the cross drifts, in the manner that has been described.

According to this plan a very extensive colliery may be worked from one pit, but horses must be used to draw the coal underground; and if the coal be thin, part of either the floor or roof must be removed to give sufficient headway. In speaking of Newtown colliery, the great benefit arising from having few pits at work, has already been mentioned, and the saving of labour both of men and horses, and the prevention of pillage, will be found to be immense. This article may therefore be concluded by the description of the most approved mode of conveying the coals from the face of the work to the pit bottom. First, a light cast iron railway must be laid from the pit bottom through all the main passages of the colliery, and branching from these, small moveable railways should be laid from the nearest point of the main passage or mother-gate, as it is usually called, to the face of the workings. When the collier has broken down the coals, another man, known by various names, as putter, hurrier, &c. is employed to fill the coal into a wicker basket, or wooden box, placed on a wooden carriage with iron wheels; this is pushed to the mother-gate along the rail way, and the putter returns with an empty box which has been left in the mother gate, and so on. When a certain number, suppose six, of these full boxes have been left at the mother gate, a waggon boy arrives from the pit, leading a horse, which draws six carriages chained together, each having an empty box on it. These boxes are lifted off, and by means of a small *crane* the full boxes are successively raised and placed on the carriages, which when thus laden are drawn by the horse along the rail way to the pit bottom, from whence the boxes are drawn up to the surface, and empty ones returned.

The minuteness with which I have described the different methods of working coal, must, I am sensible, appear tedious and unnecessary to general readers, but my object has been to explain the latest improvements so distinctly as to enable the proprietors of Irish collieries, to adopt such of them as may be judged advisable, and thus to correct the faults of the erroneous system of working now pursued throughout Ireland, and enable them to conduct their mines hereafter upon the most œconomical and scientific principles. How far I have succeeded in attaining this important end of *practical utility* must be determined by others: but I feel that I must trust to the indulgence which I have uniformly received from a candid and liberal public, for the pardon of those errors which have probably occurred in this report; and I shall be happy if my further researches on this subject should enable me to correct those inaccuracies which, in the course of so long a work, and in the prosecution of extensive inquiries into local, though important facts, it was perhaps impossible altogether to avoid.

APPENDIX.

Detail of the strata met with in the different pits and borings in the Leinster coal district, referring to the numbers marked on the map.

NO. 1, TRIAL AT BALLYNAGALL.

	Yds.	Ft.	In.
Black slate clay - -	19	2	8
Flinty slate, not penetrated			

NO. 2.—TRIAL PIT AT SPRINGHILL.

Black slate clay - -	54	0	0
Limestone, not penetrated			

NO. 3.—BOREHOLE AT OLD LEIGHLIN.

Black slate clay - -	40	0	0

NO. 4.—BORING AT NEWTOWN HARPOLE.

	Yds.	Ft.	In.
Clay and gravel	11	2	2
Blue slate clay	3	2	6
Soft brown slaty sandstone	1	1	4
Hard grey sandstone	1	0	0
Brown slaty sandstone	0	2	7
Black slate clay	0	1	5
Coal and Culm, mixed with slate clay	0	1	7
Fire clay or coal seat	3	0	1
Hard grey sandstone	6	2	5
Grey slaty sandstone	0	1	10
Grey sandstone	1	0	1
Grey slaty sandstone	3	1	3
Grey standstone	0	2	1
Blue slate clay	0	1	5
Coal	0	1	0
Fire clay or coal seat	0	2	0
Sandy seat rock	1	2	7
Blue slate clay	0	0	8
Coal	0	0	1
Slaty sandstone	0	1	6
Grey standstone, extremely hard	4	0	6
Grey slaty sandstone	1	2	6
Grey rock, extremely hard, not penetrated	2	1	10
	48	0	5

NO. 5.—FARNANS.

	Yds.	Ft.	In.
Soil and clay	2	0	0
Blue slate clay	23	0	5
Grey arenaceous slate clay	22	0	0
Blue slate clay	1	0	6
Grey slaty sandstone	2	1	0
Blue slate clay	1	0	8
Grey slaty sandstone	30	0	5
	82	0	0

NO. 6.—FARNANS.

Soil and clay	1	2	0
Grey slaty sandstone	0	1	0
Clay ironstone	0	0	1
Black slate clay	15	2	10
Grey slaty sandstone	7	0	0
Blue slate clay	1	0	0
Grey slaty sandstone	25	0	0
	50	2	11

NO. 7.—CLOGRENNAN COLLIERY.

	Yds.	Ft.	In.
Soil and clay	2	0	0
Blue slate clay	2	0	0
Grey slaty sandstone	6	0	0
Black slate clay, coal roof	3	0	0
COAL	0	0	1
Grey sandstone	1	0	0
Grey slaty sandstone	5	0	0
Black slate clay	2	0	6
COAL	0	1	0
	21	1	7

NO. 8.—CLOGRENNAN COLLIERY.

	Feet	In.			
Grey slaty sandstone			5	0	0
Hard grey sandstone			3	0	0
Striped slaty sandstone			5	0	0
Black slate clay, coal roof			5	0	0
Slaty COAL called kennel	0	2	0	1	6
COAL	1	0			
Soft slaty COAL or helve	0	4			
Fire clay or coal seat			0	2	0
Sandstone seat rock, with impressions of rushes			0	2	0
Carried forward			19	2	6

		Yd.	Ft.	In.
Brought forward	-	19	2	6
Hard gray sandstone	-	1	0	0
Black slate clay, coal roof	-	0	1	2
COAL	- - -	0	0	1
Coal seat, or fire clay	-	0	0	3
Slaty seat rock	- -	0	2	0
Striped slaty sandstone	-	2	0	0
Grey sandstone	- -	0	1	0
Striped slaty sandstone	-	4	0	0
Grey sandstone, inclining to flag		6	2	0
Hard grey sandstone	-	3	1	0
Grey slaty sandstone	-	1	1	0
Blue slate clay	- -	0	1	0
Light grey sandstone very hard		4	0	0
Grey slate clay	- -	0	2	0
Grey slaty sandstone	-	0	1	6
Slate clay	- - -	0	2	0
Grey sandstone	- -	1	1	0
Grey slaty sandstone	-	2	0	0
Grey sandstone	- -	1	0	0
Dark blue slate clay	-	6	2	0
Clay ironstone	- -	0	0	2
Dark blue slate clay	-	4	0	0
Clay ironstone	-	0	0	2
Dark blue slate clay	-	1	0	0
Slaty sandstone	- -	0	2	0
Sandstone mixed with slate clay		0	2	0
Carried forward	-	63	0	10

	Yds.	Ft.	In.
Brought forward	63	9	10
Slate clay	0	0	6
Slaty sandstone	0	0	6
Hard grey sandstone	0	1	6
Slaty sandstone	0	2	0
Dark grey sandstone	0	1	0
Slate clay	0	2	0
Clay ironstone	0	0	4
Black slate clay	1	1	0
COAL	0	0	4
Seat clay	0	0	6
Seat rock	0	1	0
Dark grey sandstone	1	1	0
Slaty sandstone approaching to slate, containing beds of clay ironstone	3	1	0
Dark grey sandstone	0	2	0
Slate clay passing into slaty sandstone	2	0	0
Slaty sandstone	6	0	0
Black slate clay, coal roof	3	0	0
COAL	0	1	0
Seat clay and seat rock	1	0	0
Slaty sandstone	5	0	0
Slate clay	0	2	6
	91	1	0

BOREHOLE AT CLOGRENNAN COLLIERY NEAR THE NEW PIT.

	Yds.	Ft.	In.
Grey sandstone -	0	2	6
Slaty sandstone - -	0	2	0
Grey sandstone -	0	1	0
Slaty sandstone -	0	1	0
Soft slaty sandstone -	1	0	0
Grey sandstone -	0	0	6
Slate clay parting -	0	0	2
Hard slaty sandstone in beds from 6 to 10 inches, with soft partings between - -	6	1	0
Slaty sandstone very hard, containing sulphur - -	0	0	5½
Slaty parting -	0	0	2½
Slaty sandstone, very hard, with sulphur - -	0	0	11
Slate clay rather soft -	1	0	0
Clay ironstone -	0	0	1
Slate clay rather soft -	1	0	8
Hard slaty sandstone -	0	0	9
Slate clay parting -	0	0	3¼
Hard slaty sandstone -	0	0	10
Slate clay - -	0	0	4½
Hard slaty sandstone -	0	1	0
Carried forward -	13	1	9

	Ft.	In.	Yds.	Ft.	In.
Brought forward			13	1	9
Slaty sandstone with many slate partings			0	1	0
Soft reddish slate clay parting			0	0	2½
Black roof slate			0	0	4
Clay ironstone			0	0	1
Black roof slate			0	1	2
Solid Coal	1	1	0	1	5½
Slaty Coal parting	0	0½			
Solid Coal, slaty structure	0	4			
Hard seat clay			0	2	0
Slaty Coal			0	0	10
Fire clay			0	2	0
			16	1	10

NO. 9. PIT AT THE RUSHES.

	Yds.	Ft.	In.
Grey sandstone, hard and coarse grained	5	0	0
Dark blue slate clay	6	2	0
Greyish blue micaceous slate clay	0	2	0
Clay ironstone	0	0	3
Grey sandstone	3	1	6
Carried forward	15	2	9

	Ft,	In.	Yds.	Ft.	In.
Brought forward -			15	2	9
Solid Coal -	1	6	1	0	0
Culm -	0	3			
Coal mixed with slate clay	1	3			
Dark grey fire clay -			1	0	0
			17	2	9

NO. 10. CORGEE COLLIERY.

	Ft.	In.	Yds.	Ft.	In.
Grey sandstone -			3	1	0
Black indurated slate clay resembling Lydian stone -			3	0	0
Blue slate clay -			6	0	0
Blue slaty sandstone -			1	1	6
Coal -	1	6			
Culm or kelve -	0	3			
Coal mixed with slate clay	1	0	0	2	9
Fire clay -			1	1	6
Sandstone seat rock -			3	0	0
			19	0	9

NO. 11. MOIRA COLLIERY.

	Ft.	In.	Yds.	Ft.	In.
Soil and clay - -			3	1	0
Brown sandstone -			6	0	6
Black slate clay, mixed with beds of clay ironstone -			8	0	0
COAL -	1	1	1	0	3
CULM mixed with slaty coal	2	2			
Fire clay - -			1	0	3
			19	2	0

NO. 12. TOLLERTON COLLIERY.

	Yds.	Ft.	In.
Grey slaty sandstone -	12	0	0
Coarse grained grey sandstone frequently containing fragments of slaty sandstone, and black slate and coal partings. Beds vary in thickness from 15 inches to 4 feet. The beds are usually separated by beds of slate or slaty sandstone from 1 inch to 2 feet in thickness	12	0	0
Carried forward -	24	0	0

	Ft.	In.	Yds.	Ft.	In.
Brought forward -			24	0	0
Coal, from ¼ of an inch to 2 inches			0	0	2
Grey sandstone, usually the coal roof, but sometimes there is a bed of slate below it which varies in thickness from 1 to 4 feet			6	0	0
Kennel -	0	4	1	0	0
Solid Coal, from 18 inches to -	2	0			
Kelve -	0	4			
Clearing -	0	10			
			31	0	2

NO. 13. FIRODA COLLIERY.

	Yds.	Ft.	In.
Soil and clay - -	3	0	0
Hard grey sandstone -	8	0	0
Blue slate clay -	8	0	0
Grey micaceous slaty sandstone	8	0	0
Coal - -	0	1	6
	27	1	6

NO. 14.—GARRENDINA HILL.

	Ft.	In.	Yds.	Ft.	In.
Grey slaty sandstone -			6	0	0
Black slate clay, with clay ironstone			6	0	0
COAL - - -	1	1	0	1	0
CULM mixed with slate	0	5			
			12	1	6

NO. 15.—GARRENDINA HILL.

	Ft.	In.			
Soil and clay - -			2	0	0
Slaty sandstone - -			3	0	0
Slate clay with clay ironstone			5	1	7
COAL - -	1	1	0	1	6
CULM mixed with slate	0	5			
			11	0	1

NO. 16.—LOON ORCHARD.

Soil and clay - -	12	1	6
Grey slaty sandstone -	3	1	6
Carried forward -	16	0	0

	Yds.	Ft.	In.
Brought forward -	16	0	0
Grey sandstone - -	0	1	8
Blue arenaceous sandstone -	2	1	1½
Clay ironstone - -	0	0	1½
Blue arenaceous slate -	5	0	6
Blue slate clay - -	1	1	8
Clay ironstone - -	0	0	1
Blue slate - - -	0	2	0
Clay ironstone - -	0	0	2
Blue slate - - -	1	1	1
Clay ironstone - -	0	0	2
Black slate - - -	1	0	7
COAL - - -	0	0	8
Coal seat - - -	0	0	11½
Seat rock - - -	0	0	3
	29	2	0½

NO. 17, PIT IN MONTEEN COLLIERY.

Clay - - -	2	0	0
Grey sandstone - -	8	0	0
Black slaty sandstone -	2	2	3
Dark grey sandstone containing calcareous impressions of muscle shells,	1	0	0
Black slaty sandstone -	0	1	6
Carried forward -	14	0	9

	Yds.	Ft.	In.
Brought forward	14	0	9
Grey sandstone	1	0	0
Grey slaty sandstone	0	1	6
Light grey sandstone	3	2	9
Black curled sandstone	0	1	0
Black slaty sandstone	1	1	0
Black curled sandstone	1	2	9
Black sandstone	1	0	0
Grey slaty sandstone	1	0	6
Grey curled sandstone	1	0	9
Black sandstone, sunk to this	0	2	0
Grey sandstone, bored from this	1	0	5
Blue arenaceous slate	0	2	0
Grey sandstone	0	1	2
Blue arenaceous slate	1	1	9
Sandstone	0	0	2½
Blue arenaceous slate	1	1	11½
Ironstone	0	0	1½
Blue arenaceous slate	1	0	3½
Ironstone	0	0	2
Blue arenaceous slate	0	1	1½
Black slate clay	1	0	1½
Black slaty sandstone	2	0	11
Ironstone	0	0	1
Black slaty sandstone	0	1	4
Ironstone	0	0	1
Grey slaty sandstone	1	1	9
Blue slaty sandstone	0	1	6
Carried forward	40	1	0

	Yd.	Ft.	In.	Yds.	Ft.	In.
Brought forward				40	1	0
Ironstone				0	0	1½
Blue arenaceous slate				1	0	2½
Ironstone				0	0	1
Blue arenaceous slate				0	1	7
Ironstone				0	0	1½
Blue arenaceous slate				2	0	3½
Ironstone				0	0	1½
Blue arenaceous slate				0	1	5
Ironstone				0	0	1½
Black slate				1	1	8
Ironstone				0	0	1
Black slate				1	0	11½
KELVE	0	2	4	2	0	4
COAL	1	1	0			
Black slate				0	2	0
				50	1	1½

NO. 18.—GENEVA COLLIERY.

	Yds.	Ft.	In.
Soil and clay	3	1	6
Grey sandstone	1	0	6
Black slaty sandstone	14	1	0
Grey sandstone	1	1	6
Carried forward	20	1	6

	Yds.	Ft.	In.	Yds.	Ft.	In.
Brought forward -				20	1	6
Black slate clay with ironstone				6	0	0
Kelve - -	0	0	8	1	2	0
Coal - -	1	0	4			
Slaty **Coal** or **Culm**	0	1	0			
Black slate clay				1	0	0
				29	0	6

NO. 19.—AHAMUCKY.

		Yds.	Ft.	In.
Passing into slaty sandstone.	Clay - -	1	0	0
	Grey sandstone -	4	2	6
	Micaceous, slate parting	0	0	2
	Grey sandstone -	1	1	2
	Micaceous, slate parting	0	0	2
	Grey sandstone -	1	0	1
	Micaceous, slate parting	0	0	2
	Grey sandstone -	1	0	1
	Micaceous, slate parting	0	0	1
	Grey sandstone -	1	0	11
	Micaceous, slate parting	0	0	1½
	Grey sandstone -	1	1	5½
	Micaceous, slate parting	0	0	1½
	Grey sandstone -	1	0	8½
	Micaceous, slate parting	0	0	2
	Grey sandstone -	0	2	8½
Carried forward -		14	1	7½

	Yds.	Ft.	In.
Brought forward	14	1	7½
Grey slaty sandstone	2	1	0
Grey sandstone, passing from slaty	1	1	0
Grey soft slaty sandstone	1	1	11
Grey slaty sandstone	0	1	9
Grey sandstone	0	0	5
Grey slaty sandstone	1	0	2
Micaceous, slate parting	0	0	2
Slaty sandstone	1	1	3
Micaceous, slate parting	0	0	1
Slaty sandstone	0	2	3
Micaceous, slate parting	0	0	2
Slaty sandstone	1	0	9
Micaceous slate parting	0	0	2
Sandstone	0	2	10½
Micaceous slate parting	0	0	1½
Sandstone, grey and slaty	1	2	3
Blue arenaceous slate clay	0	1	7
Blue slate clay	0	0	11
Clay ironstone	0	0	1½
Black slate	0	2	1
COAL	0	2	8
Black slate	0	2	6
Blue slate	0	0	8
Slaty sandstone, hard	0	1	6
Blue slate	0	2	4
Slaty sandstone	0	1	10
Blue arenaceous slate	1	2	1
Hard grey sandstone	0	1	0
Total	35	1	3

NO. 20.—MASSFORD.

Deep borehole to Four Foot Coal.

	Yd.	Ft.	In.
Sunk to seat rock, bored the remainder - -	8	0	7
Grey slaty sandstone -	2	1	6
Grey sandstone - -	0	2	7
Blue slaty sandstone -	0	2	10
Blue slate clay - -	0	1	1
Slate clay *ironstone* - -	0	0	1½
Blue slate clay - -	0	1	8½
Slate clay *ironstone* - -	0	0	1½
Black slate clay - -	0	1	4½
Hard sandstone - -	0	1	2
Black arenaceous slate -	0	2	10
Slate clay *ironstone* -	0	0	2
Black slate clay - -	0	2	6
COAL - - -	0	0	5½
Hard sandstone - -	1	0	8
Slaty sandstone - -	0	0	3½
Black stone - -	0	2	4
Grey slaty sandstone -	0	0	8
Clay ironstone - -	0	0	2
Blue slaty sandstone -	0	1	3
Grey sandstone - -	0	2	4
Blue slate clay - -	0	2	8
Hard grey sandstone - -	3	0	0
Carried forward - -	23	2	5

	Yds.	Ft.	In.
Brought forward	23	2	5
Grey slaty sandstone	0	0	6
Hard grey sandstone	1	1	1
Grey slaty sandstone	0	2	1
Clay ironstone	0	0	3
Blue slaty sandstone	1	1	7
Clay ironstone	0	0	2
Blue slate clay	0	2	0
Grey slaty sandstone	0	1	1
Hard grey sandstone	0	0	11
Grey slaty sandstone	1	2	7
Blue slaty sandstone	3	0	2
Grey sandstone	0	2	4
Slate clay	0	0	1
Hard grey sandstone	0	1	5½
Slate clay	0	0	0½
Grey slaty sandstone	0	0	4
Clay *ironstone*	0	0	2½
Grey slaty sandstone	0	1	5
Clay *ironstone*	0	0	2½
Grey slaty sandstone	1	0	10
Blue arenaceous slate clay	0	2	6
Grey sandstone	0	1	7
Blue arenaceous slate clay	0	0	11
Clay *ironstone*	0	0	1½
Grey slaty sandstone	0	1	3½
Clay *ironstone*	0	0	1½
Blue arenaceous slate clay	1	1	2
Clay *ironstone*	0	0	2½
Carried forward	40	2	8

	Yds.	Ft.	In.
Brought forward	40	2	8
Blue arenaceous slate clay	3	0	8
Clay *ironstone*	0	0	1
Blue slate clay	0	1	8
Black arenaceous slate clay	1	0	1
Black sandstone	0	2	11
Micaceous slate clay	0	0	1
Grey sandstone	1	0	7
Grey slaty sandstone	2	1	6
Clay *ironstone*	0	0	1½
Grey slaty sandstone	1	1	9½
Clay *ironstone*	0	0	2
Blue arenaceous slate clay	3	0	8
Clay *ironstone*	0	0	2
Blue arenaceous slate clay	1	0	2
Clay *ironstone*	0	0	2
Blue arenaceous slate clay	1	0	6
Clay *ironstone*	0	0	1½
Blue arenaceous slate clay	0	1	6½
Clay *ironstone*	0	0	1½
Blue arenaceous slate clay	2	0	1½
Clay *ironstone*	0	0	2
Strong blue slate clay	0	2	1
Slate clay *ironstone*	0	0	1½
Black slate clay	1	0	3½
Slate clay *ironstone*	0	0	1
Black slate clay	0	2	9
Slate clay *ironstone*	0	0	1
Black slate clay	1	0	9
Carried forward	64	1	3

	Yds.	Ft.	In.	Yds.	Ft.	In.
Brought forward				64	1	3
Strong KELVE	0	1	11	1	2	5
KELVE mixed with slate clay	0	1	0			
KELVE	0	2	6			
COAL				1	0	0
Slate clay				0	0	5½
COAL	0	1	2½	0	1	7½
KELVE and COAL	0	0	1½			
COAL	0	0	3½			
Very hard slate clay				0	0	3
Clay *ironstone*				0	0	1
Slate black and gully				0	0	2
				68	0	3

NO. 21.—MONEEN ROE, NEAR MASSFORD.

	Yds.	Ft.	In.
Pit sunk, bored the remainder	15	2	0
Grey slaty sandstone	2	1	0
Black slaty sandstone, hard	0	0	7
Grey slaty sandstone	1	2	5
Clay *ironstone*	0	0	2
Black slate clay	0	1	10
Grey slaty sandstone	0	1	6
Clay *ironstone*	0	0	2
Carried forward	21	0	8

	Yds.	Ft.	In.
Brought forward	21	0	8
Strong slate clay	1	2	0
Clay *ironstone*	0	0	2
Slate clay	1	0	2
Grey slaty sandstone	0	1	8
Hard grey sandstone	1	0	6
Blue arenaceous slate clay	0	1	8
Clay *ironstone*	0	0	1½
Slate clay	1	0	7
Clay *ironstone*	0	0	2½
Slate clay	0	1	4
Gray slaty sandstone	0	1	2½
Grey sandstone	0	1	5
Black slaty sandstone	0	0	3
Clay *ironstone*	0	0	1½
Slate clay	1	0	0
COAL	0	0	2
Slate clay	0	0	3
Grey sandstone	0	0	4
Grey slaty sandstone	0	0	9
Hard grey sandstone	0	2	2
Micaceous slate clay	0	0	2
Hard grey sandstone	0	1	6
Grey slaty sandstone	1	0	1
Hard grey sandstone	1	0	11½
Slate clay	0	0	0½
Hard grey sandstone	0	0	8
Grey slaty sandstone	0	1	3
Hard grey sandstone	0	1	7
Carried forward	35	1	0

	Yds.	Ft.	In.
Brought forward	35	1	0
Grey slaty sandstone	0	0	6
Hard grey sandstone	0	1	1
Micaceous slate clay	0	0	0½
Hard grey sandstone	0	1	0
Grey slaty sandstone	0	0	7
Grey sandstone	0	2	11½
Grey slaty sandstone	0	0	4
Grey sandstone	1	2	0
Micaceous slate clay	0	0	1
Grey sandstone	0	1	7
Grey slaty sandstone	1	1	11
Clay *ironstone*	0	0	2
Blue arenaceous slate clay	2	0	9
Clay *ironstone*	0	0	1
Blue arenaceous slate clay	0	1	8
Slate clay	0	1	7
Hard black slaty sandstone	0	2	1
Hard grey sandstone	0	2	0
Grey slaty sandstone	1	0	9
Clay *ironstone*	0	0	1
Grey slaty sandstone	0	2	1
Clay *ironstone*	0	0	2
Blue arenaceous slate clay	1	0	8
Clay *ironstone*	0	0	1
Blue arenaceous slate clay	1	1	9
Clay *ironstone*	0	0	4
Blue arenaceous slate clay	1	0	4
Grey sandstone	0	1	4
Carried forward	52	2	0

	Yds.	Ft.	In.
Brought forward	52	2	0
Grey slaty sandstone	0	2	9
Grey sandstone	0	2	5
Grey slaty sandstone	0	1	6
Clay *ironstone*	0	0	1½
Grey slaty sandstone	1	1	8½
Coarse grained blue slate clay	0	1	5
Clay *ironstone*	0	0	2
Blue arenaceous slate clay	0	2	11
Clay *ironstone*	0	0	2
Blue slate clay	0	2	9
Blue arenaceous slate clay	0	0	4
Grey slaty sandstone	1	1	6
Grey sandstone	1	1	9½
Micaceous slate clay parting	0	0	1½
Blue arenaceous slate clay	1	0	0
Clay *ironstone*	0	0	2
Blue arenaceous slate clay	0	2	1
Hard grey sandstone	0	2	8
Grey slaty sandstone	1	2	6½
Blue arenaceous slate clay	0	0	11½
Clay *ironstone*	0	0	1½
Blue arenaceous slate clay	0	0	2½
Very hard clay *ironstone*	0	0	8
Blue arenaceous slate clay	2	0	8
Clay *ironstone*	0	0	1½
Blue slaty sandstone flag	0	0	3
Slate clay	0	1	7
Clay *ironstone*	0	0	1½
Slate clay	0	1	3
Carried forward	70	1	8

	Yds.	Ft.	In.
Brought forward	70	1	8
Clay *ironstone*	0	0	1½
Blue slate clay	0	0	9
Clay *ironstone*	0	0	1
Blue slate clay	0	1	7
Clay *ironstone*	0	0	1½
Blue slate clay	0	2	7
Clay *ironstone*	0	0	2
Blue slate clay	0	1	0
Clay *ironstone*	0	0	1½
Blue slate clay	0	0	5
Clay *ironstone*	0	0	1
Blue slate clay	0	0	6
Clay *ironstone*	0	0	1
Blue slate clay	0	0	8
Clay *ironstone*	0	0	1
Blue slate clay	0	0	11
Clay *ironstone*	0	0	1
Blue slate clay	0	0	7
Clay *ironstone*	0	0	1½
Blue slate clay	0	0	5
Clay *ironstone*	0	0	1
Blue slate clay	0	0	5
Clay *ironstone*	0	0	1
Blue slate clay	0	0	10
Clay *ironstone*	0	0	1½
Blue slate clay	0	1	3
Clay *ironstone*	0	0	1½
Blue slate clay	0	0	6
Carried forward	75	0	7

	Ft.	In.	Yds.	Ft.	In.
Brought forward			75	0	7
Clay *ironstone*			0	0	1
Blue slate clay			0	0	6
Clay *ironstone*			0	0	1½
Blue slate clay			0	1	4½
Clay *ironstone*			0	0	1
Blue slate clay			0	2	6
Clay *ironstone*			0	0	1
Blue slate clay			0	0	5
Clay *ironstone*			0	0	1½
Blue slate clay			0	0	4
Clay *ironstone*			0	0	1
Blue slate clay			0	0	6½
Clay ironstone			0	0	1
Black slate clay			3	0	5
KELVE and pyrites	2	10	2	0	10
COAL	4	0			
Slate clay			0	2	2
Grey sandstone, not penetrated			0	0	5
Total depth bored			83	1	9

NO. 22.—BORING BELOW 3 FOOT SEAM ON THE TOP OF COOLBANE HILL.

	Yds.	Ft.	In.
Blue arenaceous slate clay	1	1	10
Clay *ironstone*	0	0	1½
Carried forward	1	1	11½

	Yds	Ft.	In.
Brought forward	1	1	11½
Blue arenaceous slate clay	2	1	7
Clay *ironstone*	0	0	2
Blue arenaceous slate clay	2	1	8
Clay *ironstone*	0	0	2½
Blue slate clay	0	2	8
Clay *ironstone*	0	0	2
Blue slate clay	0	2	3½
Clay *ironstone*	0	0	2
Blue slate clay	1	0	0½
Clay *ironstone*	0	0	2
Blue slate clay	1	2	1
Clay *ironstone*	0	0	1
Black slate clay	1	1	10
FIRST BED OF THREE FOOT COAL	1	0	0
Coal seat, bored from this	0	2	0
Coal seat	1	1	2
Grey slaty sandstone	0	2	6
Slate clay	1	2	0
Clay *ironstone*	0	0	2
Slate clay	1	1	9
Grey sandstone	0	1	5
Grey slaty sandstone	0	1	0
Grey sandstone	0	2	4
Grey slaty sandstone	1	2	3
Grey sandstone	0	2	3
Micaceous slate clay	0	0	3
Grey slaty sandstone	0	2	6
Grey sandstone	0	0	8
Carried forward	25	1	4

				Yds.	Ft.	In.
Brought forward				25	1	4
Grey slaty sandstone				0	0	8
Clay *ironstone*				0	0	2
Slate clay				1	2	8
Grey sandstone				0	2	11
Black arenacous slate clay				0	1	0
Soft black smut	0	0	1	0	0	3
COAL	0	0	2			
Coal seat				1	0	7½
Seat rock or grey sandstone				0	1	4
Grey slaty sandstone				0	1	0
Grey sandstone				0	1	3
Grey slaty sandstone				0	0	8
Grey sandstone				2	0	6
Micaceous slaty clay				0	0	2
Grey slate sandstone				0	2	10
Grey sandstone				0	2	8
Micaceous slate clay				0	1	0
Grey slaty sandstone				0	2	10
Clay *ironstone*				0	0	2½
Slate clay				0	2	8
Clay *ironstone*				0	0	2
Slate clay				0	1	8
Grey sandstone				3	2	11½
Micaceous slate clay				0	0	1
Grey sandstone				0	2	8½
Micaceous slate clay				0	0	3
Grey sandstone				3	1	1
Grey slaty sandstone				2	0	1
Light grey sandstone				0	0	8½
Carried forward				49	0	5½

				Yds.	Ft.	In.
Brought forward				49	0	5½
Grey slaty sandstone				2	2	7
Grey sandstone				0	0	5
Grey slaty sandstone				0	0	6
Slate clay				1	0	4½
Grey sandstone				0	0	9½
Grey slaty sandstone				0	1	5
Grey sandstone				0	1	1½
Grey slaty sandstone				0	2	1
Clay *ironstone*				0	0	3
Slate clay				1	2	3
Clay *ironstone*				0	0	3
Grey slaty sandstone				0	1	10
Clay ironstone				0	0	3
Slate clay black				0	2	11
Soft black smut	0	0	3	0	0	6½
Coal	0	0	3½			
Coal seat or fire clay				2	1	8
Seat rock or grey sandstone				1	0	6
Grey slaty sandstone				0	1	0
Grey sandstone,				1	0	3
Grey slaty sandstone				0	1	6
Light grey sandstone				1	1	0
Micaceous slate clay				0	0	5
Light grey sandstone				0	1	5½
Sandstone not penetrated				15	1	2
Total depth				82	0	0

NO. 23.—TOURTANÈ.

	Yds.	Ft.	In.
Clay - - -	8	0	0
Slaty sandstone, *sunk to this and bored from it* - - -	5	2	3
Grey sandstone with partings	4	0	1
Ironstone, probably slaty -	0	0	6
Slaty sandstone - -	3	0	0
Clay ironstone - -	0	0	3½
Hard slaty sandstone -	2	1	10
Grey slaty sandstone -	1	1	10
Dark grey sandstone -	1	0	4
Slaty sandstone - -	2	2	8
Hard grey sandstone -	1	0	8
Grey slaty sandstone -	0	2	4
Clay ironstone - -	0	0	2
Blue slate clay - -	1	0	6
Clay ironstone - -	0	0	3
Blue slate - -	0	2	6½
Blue arenaceous slate -	9	1	1½
Clay *ironstone* - -	0	0	1
Blue slate clay - -	0	2	9
Clay *ironstone* - -	0	0	1
Black slate -	0	0	6
COAL - -	0	1	0
Coal seat not penetrated -	0	0	6
	44	1	3½

NO. XXIV.—CRUTENCLOGH.

	Yds.	Ft.	In.
Clay	4	2	3
Blue arenaceous slate	4	0	0
Black curled sandstone	4	0	0
Grey slaty sandstone	2	0	0
Black curled sandstone	1	0	0
Light grey sandstone	8	0	0
Black arenaceous slate	1	1	6
Clay ironstone	0	0	8
Black arenaceous slate with running balls of *ironstone* (sunk to this)	4	1	6
Clay *ironstone*, (bored from this)	0	0	8½
Blue arenaceous slate	0	2	0
Clay *ironstone*	0	0	2½
Blue slate	1	2	3½
Soft grey slaty sandstone	1	1	11
Clay *ironstone*	0	0	2
Blue arenaceous slate	0	2	10
Clay *ironstone*	0	0	2½
Black slate	0	2	7
COAL	0	0	9
Coal seat	1	2	7½
Blue arenaceous slate	1	1	10
Ironstone	0	0	2
Blue slate	0	2	10
ronstone	0	0	3
rey slaty sandstone	0	2	8
Carried forward	41	2	1½

	Yds.	Ft.	In.
Brought forward -	41	2	1½
Grey sandstone (extremely hard)	0	0	2½
Total depth bored -	41	2	4

NO. 25.—MAYO, NEAR CLONBROCK RIVER.

				Yds.	Ft.	In.
Clay - -				3	1	6
Blue slaty sandstone -				7	1	4
Black slate clay				2	2	8
Clay *ironstone* - -				0	0	2
Black slate clay - -				6	1	6
Clay *ironstone* - -				0	0	2
Black slate clay - -				2	0	0
Clay *ironstone* - -				0	0	2
Black slate clay - -				1	2	0
Clay *ironstone* - -				0	0	2
Black slate clay -				1	0	2
COAL -	0	0	8	0	2	0
KELVES -	0	1	4			
Coal seat - -				0	2	7
Total depth -				26	2	5

NO. 26.—BOREHOLE NEAR DRUMMAGH COLLIERY.

	Yds.	Ft.	In.
Clay, gravel and sand	24	0	6
Grey slaty sandstone	6	0	1
Clay *ironstone*	0	0	2
Blue slate clay	0	0	8
Grey slaty sandstone	7	0	0
Blue arenaceous slate clay	8	2	1
Grey slaty sandstone	0	0	6
Blue arenaceous slate clay	3	0	1
Clay *ironstone*	0	0	2
Blue slate clay	3	0	10
Clay *ironstone*	0	0	2
Black slate clay	0	2	10
COAL	0	1	0
Fire clay	0	2	0
Grey sandstone	0	0	8
Blue slate clay	0	1	9
Hard grey sandstone	0	0	9
Blue slate clay	0	2	1
Grey sandstone	0	1	5
Blue slate clay	0	0	8
Grey sandstone	0	1	0
Blue slate clay	0	1	7
Grey sandstone,	0	0	5
Blue slate clay	0	1	7
Grey sandstone	0	0	8
Blue slate clay	1	1	0
Carried forward	60	0	8

	Yds.	Ft.	In.
Brought forward	60	0	8
Hard grey sandstone	1	2	3
Blue slate clay	2	2	3
Clay ironstone	0	0	2
Blue slate clay	0	1	2
Hard grey sandstone	0	1	9
Blue slate clay	2	0	8
Grey sandstone	0	0	5
Blue slate clay	0	1	6
Grey sandstone	0	0	6
Blue slate clay	0	1	5
Grey sandstone	0	0	3
Blue slate clay	0	0	9
Hard grey sandstone	3	1	11
Blue slate clay	8	2	4
Hard grey sandstone	0	1	2
Blue micaceous slate clay	0	0	10
Hard grey sandstone	0	2	1
Blue slate clay	0	0	2
Hard grey sandstone	1	0	8
Blue slate clay	0	0	5
Grey sandstone	2	0	0
Blue arenaceous slate clay	2	2	6
Blue slate clay	1	2	6
Grey slaty sandstone	5	1	6
Total depth bored to	96	2	10

NO. 27.—CLONBROCK.

	Yds.	Ft.	In.
Clay sand and gravel	15	2	4
Brown slate clay	1	1	0
Clay *ironstone*	0	0	2
Blue slate clay	1	1	0
Grey slaty sandstone	1	2	5
Blue slate clay	3	2	1
Clay *ironstone*	0	0	2
Blue slate clay	0	1	4
Grey slaty sandstone	0	1	0
Blue slate clay	9	0	8
Clay *ironstone*	0	0	2
Blue slate clay	2	2	2
Clay *ironstone*	0	0	2
Black slate clay	2	0	6
COAL	0	1	0
Total depth	39	1	2

NO. 28.—HILL OF DOONANE NEAR TURNPIKE.

Blue slate clay	6	0	0
Black slate clay with *ironstone*	6	0	0
COAL	0	1	0
Total	12	1	0

BORINGS AND SINKINGS TO THE FIRST BED OF THREE FOOT COAL.

NO. 29.—NEWTOWN ENGINE PIT.

	Yds.	Ft.	In.
Clay sand and gravel - -	25	0	0
Blue slate clay - -	2	0	0
Coal - -	0	1	0
Soft white fire clay - -	0	0	8
Coal - - -	0	0	10
Fire clay - - -	0	1	0
Sandstone seat rock - -	1	1	4
Blue slate clay - -	1	1	2
Grey slaty sandstone -	2	0	0
Grey calcareous sandstone -	0	1	0
Black slate clay with ironstone -	0	1	6
Grey calcareous sandstone -	0	0	10
Grey slaty sandstone -	3	0	2
Grey calcareous sandstone -	4	0	0
Blue slate clay - -	1	0	0
Grey calcareous sandstone -	1	2	2
Micaceous slate clay -	0	0	9
Gray calcareous sandstone -	2	2	11
Micaceous slaty sandstone -	7	1	0
Black slate clay - -	11	2	8
Coal - - - -	1	0	8
Coal seat - - -	1	0	7
Total	68	1	3

NO. 30.—CLONBROCK TO THE EAST OF NEWTOWN ENGINE PIT.

	Yds.	Ft.	In.
Soil clay and gravel - -	27	1	0
COAL - - - -	0	2	9
Total	28	0	9

NO. 31.—PIT TO THE SOUTH OF NEWTOWN ENGINE PIT.

Soil clay and gravel -	16	1	9
COAL - - -	1	0	3
Total depth	17	2	0

NO. 32.—CLONEEN COLLIERY NEAR CRUTTYARD.

Clay - - - -	5	0	0
Blue arenaceous slate clay -	1	1	6
Clay *ironstone* - -	0	0	2
Grey sandstone - -	3	1	6
Clay *ironstone* - -	0	0	3
Grey sandstone - -	1	2	8
Micaceous slate clay -	0	0	1
Light grey sandstone -	2	0	0
Micaceous slate clay - .	0	0	4
Light grey sandstone - -	12	1	4
Black slaty sandstone (curled) -	2	0	0
Micaceous slate clay - -	0	0	1
Blue arenaceous slate clay -	2	1	6
Clay *ironstone* - -	0	0	2
Blue arenaceous slate clay -	0	1	11
Black slate clay - -	3	1	6
COAL - - - -	0	2	10
Total	36	0	10

NO. 33.—MASSFORD COLLIERY.

	Yds.	Ft.	In.
Soil and clay - -	14	2	0
Grey sandstone - -	0	0	7
Light grey sandstone (white stone)	0	0	2
Grey sandstone - -	0	1	5½
Hard grey slaty sandstone -	0	1	2½
Hard blue arenaceous slate clay	0	1	11
Clay *ironstone* - -	0	0	2½
Blue arenaceous slate clay -	2	2	8
Clay *ironstone* - -	0	0	2
Blue slate clay - -	2	1	10
Clay *ironstone* - -	0	0	1½
Blue slate clay - -	1	0	6
Clay *ironstone* - -	0	0	2
Black slate clay - -	1	2	11½
COAL - - -	0	2	11
Total	26	0	10½

NO. 34—COOLBANE HILL—SECTION OF THE STRATA BETWEEN THE FIRST BED OF THREE FOOT COAL, THE DOUBLE SEAM, AND THE SECOND OR UPPER BED OF THREE FOOT COAL.

Clay - - -	3	1	0
Blue slate clay - -	7	1	0
Ironstone - - -	0	0	2
Carried forward -	10	2	2

		Yds.	Ft.	In.
	Brought forward	10	2	2
	Black slate clay	0	2	10
	Ironstone	0	0	2
	Blue slate	3	2	11
	Ironstone	0	0	1
	Black slate	2	0	4
	COAL	1	0	0
	Coal seat	1	0	0
	Blue slate with vegetable impressions and small nodules of ironstone, with pyrites	5	2	10
Double seam.	COAL	0	1	0
	COAL SEAT	0	1	6
	COAL	0	1	0
	Coal seat	0	1	6
	Blue arenaceous slate clay	12	1	0
	Grey sandstone	2	1	3
	Grey slaty sandstone	0	1	9
	Grey sandstone	1	0	7
	Grey slaty sandstone	3	2	8
	Grey sandstone	1	2	0½
	Blue arenaceous slate clay	1	1	2
	Ironstone	0	0	1½
	Blue arenaceous slate clay	2	1	7
	Ironstone	0	0	2
	Blue arenaceous slate clay	2	1	8
	Ironstone	0	0	2½
	Blue slate clay	0	2	8
	Ironstone	0	0	2
	Carried forward	57	0	4½

	Yds.	Ft.	In.
Brought forward	57	0	4½
Blue slate clay	0	2	3½
Ironstone	0	0	2
Blue slate	1	0	0½
Ironstone	0	0	2
Blue slate	1	2	1
Ironstone	0	0	1
Black slate	1	1	10
COAL	0	2	10
Total	63	0	10½

DETACHED BORINGS.

NO. 35.—LANDS OF SLATT.

Soil clay and gravel	10	1	0
Blue slaty sandstone	7	0	0
Blue slate clay	7	1	4
Grey slaty sandstone	6	0	7
Blue arenaceous slate clay	12	0	2
Black slate clay	6	2	5
Clay *ironstone*	0	3	0
Black slate clay	3	0	4
Black slate, with clay *ironstone*	7	1	0
Total	61	0	10

NO. 36.—LANDS OF SLATT.

	Yd.	Ft.	In.
Soil clay and gravel	1	1	4
Blue slate clay	10	0	0
Grey slaty sandstone	0	0	6
Total	11	1	10

NO. 37.—PIT OF MOYHORA.

	Ft.	In.	Yd.	Ft.	In.
Soil and clay			2	0	2
Ferruginous slate clay			2	0	8
Light grey sandstone			6	0	7
Grey slaty sandstone			3	1	0
Black arenaceous slate clay			0	1	7
Clay *ironstone*			0	0	1½
Black arenaceous slate clay			1	1	3
Clay *ironstone*			0	0	2
Blue arenaceous slate clay			0	1	6
Clay *ironstone*			0	0	1½
Blue arenaceous slate clay			1	1	2
Clay *ironstone*			0	0	1½
Blue arenaceous slate clay			0	1	6
Clay *ironstone*			0	0	2
Black slate clay			0	2	0
KELVE, mixed with slate	1	6	1	0	0
COAL	1	6			
Fire clay			0	1	6
Fire clay mixed with COAL			0	1	6
Total			21	0	2½

	Yds.	Ft.	In.
Brought forward	57	0	4½
Blue slate clay	0	2	3½
Ironstone	0	0	2
Blue slate	1	0	0½
Ironstone	0	0	2
Blue slate	1	2	1
Ironstone	0	0	1
Black slate	1	1	10
COAL	0	2	10
Total	63	0	10½

DETACHED BORINGS.

NO. 35.—LANDS OF SLATT.

Soil clay and gravel	10	1	0
Blue slaty sandstone	7	0	0
Blue slate clay	7	1	4
Grey slaty sandstone	6	0	7
Blue arenaceous slate clay	12	0	2
Black slate clay	6	2	5
Clay *ironstone*	0	3	0
Black slate clay	3	0	4
Black slate, with clay *ironstone*	7	1	0
Total	61	0	10

NO. 36.—LANDS OF SLATT.

	Yd.	Ft.	In.
Soil clay and gravel	1	1	4
Blue slate clay	10	0	0
Grey slaty sandstone	0	0	6
Total	11	1	10

NO. 37.—PIT OF MOYHORA.

Soil and clay			2	0	3
Ferruginous slate clay			2	0	8
Light grey sandstone			6	0	7
Grey slaty sandstone			3	1	0
Black arenaceous slate clay			0	1	7
Clay *ironstone*			0	0	1½
Black arenaceous slate clay			1	1	3
Clay *ironstone*			0	0	2
Blue arenaceous slate clay			0	1	6
Clay *ironstone*			0	0	1½
Blue arenaceous slate clay			1	1	2
Clay *ironstone*			0	0	1½
Blue arenaceous slate clay			0	1	6
Clay *ironstone*			0	0	2
Black slate clay			0	2	0
	Ft.	In.			
KELVE, mixed with slate	1	6	1	0	0
COAL	1	6			
Fire clay			0	1	6
Fire clay mixed with COAL			0	1	6
Total			21	0	2½

NO. 38.—BOREHOLE MADE BY THE GRAND CANAL COMPANY ON THE SIDE OF AHARINAGH HILL.

	Yds.	Ft.	In.
Soil clay and gravel	1	2	3
Brown slate clay	2	1	6
COAL	0	0	3
Fire clay	0	1	6
Black slate clay	1	0	7
Grey slaty sandstone	2	0	9
Grey sandstone	2	1	7
Black arenaceous slate clay	0	0	10
Clay *ironstone*	0	0	2
Black arinaceous slate clay	2	0	4
Clay *ironstone*	0	0	1
Blue slate clay	0	1	1
Clay *ironstone*	0	0	5
Black arenaceous slate clay	2	2	6
Clay *ironstone*	0	0	1
Blue slate clay	1	2	2
Clay *ironstone*	0	0	[illegible]
Black slate clay	0	1	8
Grey slaty sandstone	0	0	10
Fireclay	1	2	11
Hard grey sandstone	0	1	8
White sandstone	1	1	2
Grey slaty sandstone	7	2	[illegible]
Blue arenaceous slate clay	2	1	
Black slate clay	6	0	
Carried forward	39	1	[illegible]

	Yds	Ft.	In.
Brought forward -	39	1	0½
Grey slaty sandstone -	14	0	7
Grey sandstone - -	14	1	0
Black slate clay - -	9	1	4
Clay *ironstone* - -	0	0	4
Blue slate clay - -	18	1	0
Grey slaty sandstone -	4	2	2
Black slate clay - -	3	0	0
COAL - - -	0	0	2
Fire clay or coal seat -	0	1	2
Clay *ironstone* - -	0	0	6½
Grey slaty sandstone -	0	1	8
Black slate clay with ironstone	10	1	10
Grey slaty sandstone -	0	0	7
Black slate clay with ironstone	2	2	3
Total depth -	118	0	8

NO. 39.—GRAND CANAL COMPANY'S BOREHOLE ON THE LANDS OF KILGOREY.

	Yds	Ft.	In.
Clay and brown earth -	10	1	3
Grey slaty sandstone -	3	1	0
Blue slate clay - -	4	2	5
Grey slaty sandstone -	7	1	10
Blue slate clay - -	28	0	1
Clay *ironstone* - -	0	0	1
Carried forward -	54	1	1

	Yds	Ft.	In.
Brought forward - -	54	1	1
Blue slate clay - -	2	0	4
Clay *ironstone* - -	0	0	1
Black slate clay - -	3	0	0
Clay *ironstone* - -	0	0	1
Dark blue slate clay -	1	2	0
Clay *ironstone* - -	0	0	1½
Blue slate clay - -	0	2	0
Clay *ironstone* - -	0	0	2½
Blue slate clay with balls of clay ironstone - -	2	0	8
Hard black slaty sandstone	3	2	7
Black arenaceous slate clay -	1	2	6
Hard grey slaty sandstone	11	2	7
Clay *ironstone* - -	0	0	2
Blue arenaceous slate clay -	5	1	6
Total depth -	87	0	11

PRICES OF SINKING IN THE CASTLECOMER AND NEIGHBOURING COLLIERIES.

DEPTHS OF PITS.

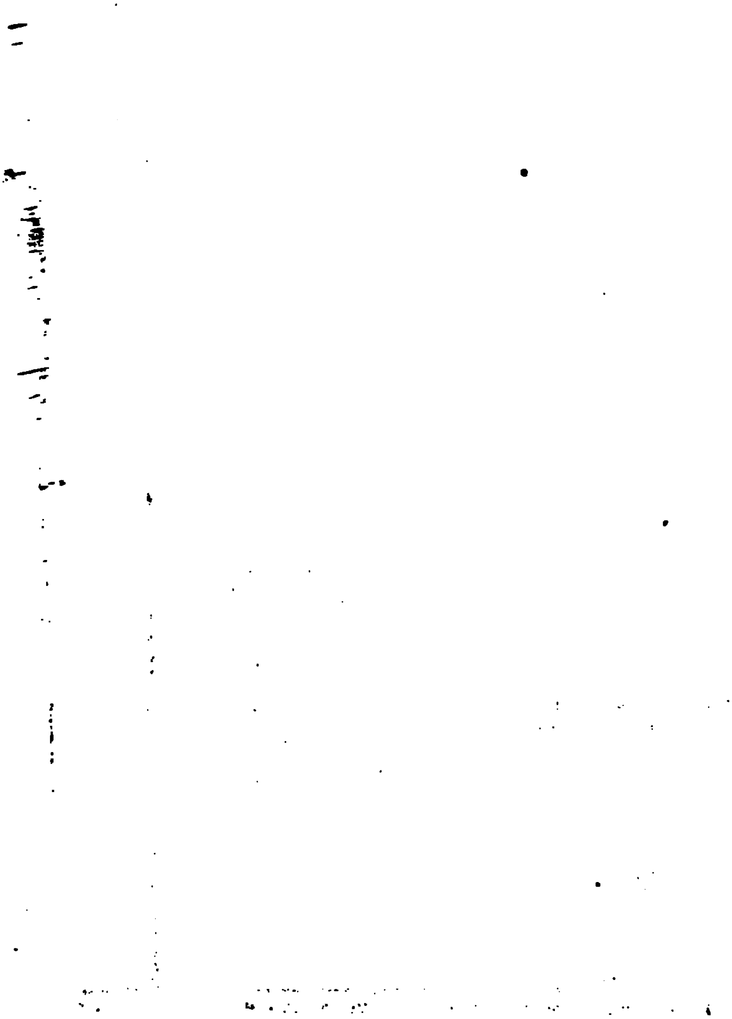
	From the surface to 15 Yds.							From 15 to 30 Yards.							From 30 to 45 Yards.							From 45 to 60 Yards.						
	£.	s.	d.		£.	s.	d.	£.	s.	d.		£.	s.	d.	£.	s.	d.		£.	s.	d.	£.	s.	d.		£.	s.	d.
Slate per Yard	0	10	0	to	0	15	0	1	0	0	to	1	5	0	1	10	0	to	2	0	0	2	10	0	to	3	0	0
Slaty sandstone	1	0	0	to	1	10	0	1	15	0	to	2	5	0	2	10	0	to	3	0	0	3	10	0	to	4	0	0
Hard sandstone	1	10	0	to	2	0	0	2	10	0	to	3	0	0	3	10	0	to	4	0	0	4	10	0	to	5	0	0

	Yds	Ft.	In.
Brought forward	54	1	1
Blue slate clay	2	0	4
Clay *ironstone*	0	0	1
Black slate clay	3	0	0
Clay *ironstone*	0	0	1
Dark blue slate clay	1	2	0
Clay *ironstone*	0	0	1½
Blue slate clay	0	2	0
Clay *ironstone*	0	0	2½
Blue slate clay with balls of clay ironstone	2	0	8
Hard black slaty sandstone	3	2	7
Black arenaceous slate clay	1	2	6
Hard grey slaty sandstone	11	2	7
Clay *ironstone*	0	0	2
Blue arenaceous slate clay	5	1	6
Total depth	87	0	1

PRICES OF SINKING IN THE CASTLECOMER AND NEIGHBOURING COLLIERIES.

DEPTHS OF PITS.

	From the surface to 15 Yds.	From 15 to 30 Yards.	From 30 to 45 Yards.	From 45 to 60 Yards.
	£. s. d. £. s. d.	£. s. d. £. s. d.	£. s. d. £. s. d.	£. s. d. £. s. d.
Slate per Yard	0 10 0 to 0 15 0	1 0 0 to 1 5 0	1 10 0 to 2 0 0	2 10 0 to 3 0 0
Slaty sandstone	1 0 0 to 1 10 0	1 15 0 to 2 5 0	2 10 0 to 3 0 0	3 10 0 to 4 0 0
Hard sandstone	1 10 0 to 2 0 0	2 10 0 to 3 0 0	3 10 0 to 4 0 0	4 10 0 to 5 0 0



Geological Plan

Explanation of the colours

▨ *Granite and Sienite*

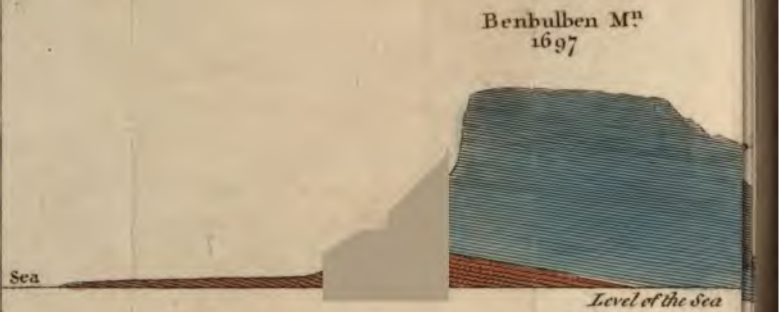
▨ *Primary Slate*

▨ *Old Sandstone*

▨ *Limestone*

▨ *Black slate clay.*
▨ *Sandstone* …… } *Coal Formation*
▨ *Coal* ……………

COUNTY O



Note *The figures denote the height in feet above the Level of the Se*

OLOGICAL AND MINING

SURVEY

OF THE

NNAUGHT COAL DISTRICT

IN IRELAND.

Y RICHARD GRIFFITH, JUN. ESQ.
OR GENERAL OF HIS MAJESTY'S ROYAL MINES IN
AND, MINING ENGINEER TO THE DUBLIN SOCIETY,
F. R. S. EDINBURGH, &c. &c. &c.

DUBLIN:
AISBERRY AND CAMPBELL, 10, BACK-LANE,
PRINTERS TO THE DUBLIN SOCIETY.

1818.

TO THE

RIGHT HONORABLE AND HONORABLE

THE DUBLIN SOCIETY.

MY LORDS AND GENTLEMEN,

HEREWITH I have the honor of laying before you my Geological and Mining Report of the Connaught Coal District, together with a Map and Section of the district.

In perusing the Report you will find, that the country contains abundance of bituminous Coal of excellent quality, which, from various causes, remains neglected and unwrought.

I have also entered into some detail respecting the Arigna Iron Works, in the county of Roscommon, shewing their peculiarly favorable situation, the cheapness and superior quality of all the requisite ingredients for smelting Iron, and assigning the true causes of the failure of the works.

I hope the whole will prove accep able to you, and beneficial to the Min and Manufactures of Ireland.

I have the honor to be,

My Lords and Gentlemen

Your most obedient

Humble servant,

RICHARD GRIFFITH, Jun.

Mining Engineer to the Dublin Society.

Dublin Society House,
April 24, 1818.

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ADVERTISEMENT.

THE following Report on the Connaught Coal District is intended as a Supplement to the Report on the Leinster Coal District, already published. To avoid repetition, frequent reference is made both to the text and plates contained in the Report on the Leinster Coal District, particularly to those which exhibit the different methods of working coal, as practised in England.

GEOLOGICAL AND MINING

SURVEY

OF THE

CONNAUGHT COAL DISTRICT.

AMONG the many objects of interest, which attract the attention of the Geologist, none is more worthy of pursuit than the useful art of discovering and tracing mines. But it unfortunately happens, that this species of inquiry offers less variety to the scientific observer, than the more general investigation of the great field of nature; and it has in consequence been usually left to the guidance of mere practical miners, who are wholly unacquainted with the general relations and arrangement of rocks.

Mining, as a science, is nearly unknown in this country; and our mineral resources, under the guidance of chance and ignorance, have only led to the impoverishment and disappointment of those, who have endeavoured to develope them. Under these circumstances the discovery of coal mines, being the most necessary and directly useful, claims our first attention.

In the Report on the "Leinster coal district," lately published, the situations of the principal coal fields of Ireland have been mentioned; it is unnecessary, therefore, to repeat them in this place. The Leinster coal district contains only simple carbonaceous, or non-flaming coal. The object of our present inquiry shall be the *inflammable* coal district of the north-west of Ireland, which has received the name of the Connaught coal district.

This district occupies considerable portions of the counties of Roscommon, Sligo, and Leitrim, in the province of Connaught, and part of the county of Cavan, in the province of Ulster.

Lough Allen, situated near the head of the river Shannon, forms a bason in the centre of the district; and when the navigation of the Shannon shall have been completed, it will afford a cheap and easy communication with the interior of Ireland, the city of Limerick, and, by means of the Grand and Royal canals, with the city of Dublin. It will be proved in the progress of this report, that the Connaught coal district contains extensive tracts of coal of excellent quality. Nothing then is wanting but perseverance, united with judgment in working them, to supply the steady and ample markets, which this union of navigations will open for its consumption.

But, previous to entering into the description and detail of the Connaught coal district, it may be useful to give a brief sketch of the geological position of that district, with respect to the neighbouring country, and to suggest to landed proprietors the kind of mines or other valuable mineral substance, which is likely to be found in the different species of rocks that occur in the country. It is time that it should be known that no coal is likely to be met with in the *graywacké*,* or limestone districts of the north-west of Ireland, and that we should no longer hear of, and witness useless trials for coal being commenced and persevered in at the instigation of ignorant or designing miners. There is no real scarcity of coal in Ireland; but unfortunately more money has been fruitlessly expended in searching for coal, where none was likely to be found, than in those situations, where, if sought for with judgment, there is little doubt of its being discovered.

The relative positions of the different rocks, that occur in the country, will be seen at once by reference to the geological section, which accompanies this Report.

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* In this work Professor Werner's names and classification of rocks will be adopted, as those in general use, but without any reference to theoretical speculation

All mineralogical or geological terms, or terms of art, will be found explained in the glossary. See appendix, No. 3.

The elevations above the sea, as given in the section, were ascertained by observations carefully made with one of Troughton's large barometers, and calculated according to the Formula of La Place; and the distances between the different points were taken from county maps on a large scale.

The range of primary mountains, which extend from Foxford, in the county of Mayo, to Colooney, in the county of Sligo, and end two miles to the north-east of Manor Hamilton, may be said to form the base of the strata of that part of the north-west of Ireland. Upon this base rests the *first or old floetz sandstone*, which is succeeded by the *first floetz limestone;* and this again by the series of rocks which accompany coal. This series forms the uppermost strata in the country.

This range of primary mountains is, for the most part, composed of *mica slate*; but in some places the whole suite of primary rocks may be observed. This is particularly the case at Benbo mountain, near Manor Hamilton.—The elevation of this mountain above the sea * is 1403 feet. The summit, and about eight hundred feet immediately below it, are composed of a fine grained *granite*, having the appearance of *gneiss*, from the arrangement of the *mica* in one direction; but there is no appearance of stratification. The granite is covered on both sides of the mountain by a stratified *micaceous quartz rock*, dipping in the direction of its declivity at an angle of 50° from the horizon. At the base of the mountain a great variety of rocks is visible, *hornblende rock*, *hornblende slate*, and mica slate, with a profusion of garnets. Large masses of a beautiful Syenite, with green *hornblende*; also serpentine and green Steatite, thickly studded with precious garnets, were found in a stream at the base of the mountain, next to Lurganboy. Probably these rocks and many others occur in *Situ*, in a minor mountain situated between Benbo and Lurganboy, as they are to be found in all the walls of the neighbourhood. On the western base of Benbo mountain some of these rocks are found much decomposed, and clays of various colours are met with, as red, yellow, black, and bluish white. Of the last, considerable quantities have been raised, and used instead of fuller's earth in washing floors. It feels soapy, and

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* This elevation was ascertained by a chain of barometrical observations, made with *one* of Troughton's large barometers. First, by an observation at the sea at Sligo harbour, and secondly, on the same day, at a station in Manor Hamilton. The height of the summit of Benbo mountain above Manor

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Hamilton was ascertained some days after by the mean of two observations taken at Manor Hamilton, one in the morning, and another in the evening of the same day; and the observations on Benbo were made in the middle of the same day.

resembles decomposed steatite. Large masses of sulphur pyrites are found amongst it. The pits were so closed up, that it was not possible to determine the relations of this steatitic clay with the stratification of the mountain. Possibly it may belong to a vein of steatite.

The western base of Benbo mountain is traversed by a metallic vein, containing copper pyrites. It was formerly wrought, though apparently to no great extent. Some of the shafts and levels are still visible. The vein runs in a north-east and south-west direction, from the base of Benbo mountain, across the limestone strata, * which cover the primary country between Benbo and the village of Lurganboy. It is remarkable that sulphuret of lead, and no copper, was found in the workings on the vein, which were made in the limestone country on the lands of Shanna, a quarter of a mile to the south of Lurganboy. This vein has been worked in many places between Shanna and the workings at the base of Benbo mountain; and some of the excavations are so large, that the vein must have been both rich and very wide to defray the expence, which must have been incurred. The difficulty of freeing the mine from water, at a time when mining machinery

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* In this particular direction the old sandstone, which is generally interposed between the primary rocks and the limestone, is wanting; though it occurs in its usual place, immediately to the south of the line of the vein.

was almost unknown, has apparently been the cause of its abandonment. The workings on the copper part of the vein have been discontinued for sixty years, but the lead mine of Shanna was partially wrought twenty years ago.*

The range of primary mountains, which extend from Foxford to Manor Hamilton, are very narrow. They rarely exceed three miles in breadth, and at some places, as at Colooney, are not a quarter of a mile broad. They are in general succeeded by beds of red, grey, or yellowish white sandstone, belonging to the first or oldest floetz sandstone formation; and, when this rock is wanting, by limestone. The sandstone formation is apparently of very unequal thickness, and very irregular in its stratification. In some places it forms lofty hills, and even ranges of mountains; and at others it does not exceed twenty or thirty feet in thickness. It is sometimes, though rarely, interstratified with a reddish or greyish sandstone slate. Where this happens, it has been mistaken for sandstone of the coal formation; and many fruitless trials for coal have been made in consequence. The hill of Fairymount, in the county of Roscommon, situated to the south of Strokestown, has been supposed to contain coal; as also the hill of Ballyfermoyle, situated to the north-east of Lough Key, and close to the coal country.

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* This information was received from a very old man, who said he had wrought in all the workings.

It is, however, separated from it by a succession of beds of limestone, exceeding one thousand feet in thickness, which rest upon the old sandstone, and run under the rocks which belong to the coal formation.

It would be tedious and unnecessary to mention all the places, where strata belonging to the first floetz sandstone formation occur in the vicinity of the Connaught coal district, rising in insulated hills from beneath the limestone. It may be sufficient to observe, as a distinguishing mark between the old floetz sandstone and the sandstone of the coal formation, that the first always lies below, and the second above the first floetz limestone.

OF THE LIMESTONE COUNTRY.

The limestone strata, which surround the Connaught coal district, form a part of the great limestone district of Ireland, which extends, with little interruption, in an east and west direction from Galway to Dublin; and from Clonmel to Enniskillen in a north and south direction.

The aspect and quality of the limestone varies very much in different places; but the difference appears to arise chiefly from the position, which the beds seen at the surface hold in the general limestone series. The lower beds are usually black; they contain considerable portions both of the siliceous and argillaceous earths, and are rarely sufficiently pure to burn into lime. They are frequently interstratified with beds of black slate clay. This impure limestone has received the name of calp from Mr. Kirwan. Calp occurs in great abundance in the neighbourhood of Dublin, from whence it extends into the county of Meath. It is also met with in various parts of the counties of Longford and Cavan, particularly where the limestone approaches the upper beds of the old or first floetz* sandstone. In the neighbourhood of Granard and Edgeworthstown, in addition to the beds of black slate clay, the calp strata is accompanied by thin layers of *lydian stone*, which are sometimes so numerous, as to give the rock a very unusual striped appearance.

In the northern part of the county of Roscommon, near to Boyle and Castle Tenison, there is a remarkable variation in the lower beds of the limestone; for, even where they are found in contact with a substratum of sandstone, the limestone is quite pure, of a light grey colour, and highly chrystaline structure, so much so as to be susceptible of a very high polish. At Knockcranny, near Castle Tenison, there is a very fine quarry of this variety of limestone; and beautiful grey marble chimney pieces have been made from solid blocks of stone raised from it.

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* Many fruitless trials have been made in search of coal in different parts of the calp country by ignorant miners, who mistook the black slate clay, with which it is interstratified, for the slate clay which forms a principal member in the coal series. Some additional remarks on the subject, and other supposed indications of coal, will be found in the introduction to the Report on the Leinster coal district.

The calp beds are usually succeeded by strata of black limestone, having a chrystaline structure. Of this species we have examples in the black marbles of Kilkenny, Limerick, Galway, Westport, and numberless other places. These marbles are exactly similar to the grey marble of Knockcranny, except in the colour; and this variation is caused by an admixture of less than one per cent of carbon in the black marbles. The marble beds graduate into light greyish blue limestone, which is the usual colour of this rock. Towards the upper beds, the colour becomes light grey, and the rock contains a profusion of petrifactions, but principally of madrepores, chamites, and archites.

The arrangement of the limestone series just described is very similar to that given in my Report on the Leinster coal district, in speaking of the stratification of the valley of the river Barrow, near to Carlow. But at Carlow all these varieties occur in a space of two miles, which in other parts of Ireland occupy a length of sixty or seventy. When the first description was written, I was not aware that the same arrangement was observable throughout the whole of the limestone district of Ireland.

It is remarkable, that in every part of Ireland wherever the limestone strata end, (by the rising up of the first floetz sandstone, or other rock from *beneath* them, or by their being *covered* by the strata which accompany coal,) they are found to be much disturbed and broken; and the disturbance is observed to have taken place equally, whether the bounding rock lies above or below the limestone. Numberless instances may be quoted of disturbances in both situations. Of the first, where the limestone ends by other rocks rising from beneath, perhaps the most remarkable instance occurs in the great caves and subterranean rivers at Cong in the county of Mayo: at this place the superfluous waters of Lough Mask are conveyed in a subterranean channel, until they burst forth near the village of Cong, from a circular gulph, fifty yards in diameter, and rushing with astonishing velocity along the surface for two hundred yards, descend rapidly into the earth through a second gulph, and entirely disappear; but still pursuing their secret course they ultimately fall into Lough Corrib. Perhaps the origin of the vast lakes Lough Corrib, and Lough Mask, which for their whole length form the boundary between the limestone and the inferior rocks, may be attributed to a similar disturbance on a larger scale. In many places the bed of a river or stream is found to be the precise boundary between the limestone and the rock, which lies below it. In the county of Longford the river Camlin forms the boundary of the limestone and old sandstone strata, for many miles in length. Disturbances similar to those at Cong have been observed in the limestone strata near the commencement of several of the coal districts of Ireland. If we except the cave of Dunmore, in the county of Kilkenny, which is mentioned in the Report on the Leinster coal district, none is more curious than the cave called Pulgulm, or the Pigeonhole, three miles to the south of Swanlinbar, in the county of Cavan. This cavern is narrow, but very lofty, and more than half a mile in length in a northern direction; in a southern direction it descends very rapidly. Its *length* was not ascertained, from the difficulty of proceding. The lower, and many of the loose rocks which cover the bottom of the cave, are as highly polished on the surface as the most finished piece of marble. This must have been effected by the dropping of water: though water falling through the fissures of a limestone cavern usually forms calcareous stalactites from the roof, and calcareous incrustations on the sides. This is not the case at Pulgulm; the difference may be attributed to the flowing of the water directly from the colliery hills into the cavern, and, meeting no limestone in the way, it is not likely to contain any thing but particles of sand and clay, the constant friction of which may have had the effect of polishing the surface of the limestone in the cavern.

There are many other remarkable caverns, and subterranean rivers along the boundary of the Connaught coal district, but it is needless to particularize them.

Whence the origin of these caves? Why are they confined to the limestone? and why do they occur so frequently in the vicinity of other rocks? These questions are difficult to resolve, but their solution would be of considerable benefit to the scientific miner, and highly interesting to the geologist.

It rarely happens, that any foreign beds occur interstratified with the limestone. At Westport, beds of sandstone occur interstratified with black limestone. Sandstone also occurs interstratified with limestone at Daly's Bridge, in the county of Cavan; and at Dunfiney Bay, in the county of Mayo, there are several alternations of black limestone, with sandstone and black slate clay. These strata are very similar to those, which occur in the metalliferous districts of Northumberland, Cumberland, Yorkshire and Derbyshire; and possibly they may contain veins of lead, though none have hitherto been discovered. Beds of sandstone have also been observed at Latt, near the town of Cavan, and in other places in that neighbourhood, interstratified with calp, and calp slate. A fruitless borehole has been made at Latt, in search of coal, and many still believe that coal may yet be found there. The sandstone, which occurs interstratified with black limestone and calp, probably belongs to the old sandstone formation. In all the cases here mentioned the occurrence takes place close to the end of the limestone, and the commencement of primary or transition rocks. There is a precipitous hill, composed of graywacké, one hundred yards to the north of the borehole at Latt.

The strata which accompany coal, in all the Irish coal districts, lie above the first floetz limestone; and no coal has ever been discovered, or is likely to be discovered interstratified with that rock.

PARTICULAR DESCRIPTION OF THE CONNAUGHT COAL DISTRICT.

It has already been mentioned, that the Connaught coal district occupies considerable portions of the counties of Roscommon, Sligo, and Leitrim, in the province of Connaught, and part of the county of Cavan in the province of Ulster. The external aspect of this district is mountainous and dreary; and its strata rise to a very considerable elevation above the secondary limestone country, on which they rest. The greatest length of the Connaught coal district in a north and south direction, from Doon Mountain to Keadue, is sixteen miles; and its greatest breadth from the hills above Swanlinbar to Killargy is sixteen miles. The area of the whole coal country within the edge of the limestone is about one hundred and fourteen thousand Irish acres, exclusive of Slieve Russel, which is detached from the great district by the limestone valley of Swanlinbar. The precise boundary of the coal country may be seen by reference to the map. It ends where the blue colour, which represents the limestone, commences.

On viewing the coal country from the south, it exhibits a steep and straight ridge of high land, rising from one thousand to twelve hundred feet above its base, and extending fourteen miles in an east and west direction, but broken in the middle by the great valley of the river Shannon, which flows through it directly from Lough Allen. The external appearance of the coal country, when seen from the east, west, or north, is very similar to that of the south. The same steep and straight external ridge is visible on all sides. The summits of these ridges are universally flat, and are covered with shallow bog.

The aspect of the interior of the coal country is different from the exterior. The centre is occupied by Lough Allen, and the different tributary streams besides the Shannon, which flow into the lake, run in straight but deep vallies, *and divide the district into four parts.*

The river Shannon takes its rise from a circular gulph, about twenty feet in diameter, but of vast depth,* situated at the southern base of

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* It is asserted by many persons much above the common rank in the country, that it was sounded with a line 200 yards in length, and that no bottom was found.

Culkagh mountain, in the interior of the district. The body of water issuing from this gulph probably flows from subterranean caverns contained in the limestone, which forms the nucleus of the mountain. The probability of this supposition will be apparent by reference to the geological section, which accompanies this Report. Though the limestone strata are not visible at the surface near the gulph, their depth beneath it was ascertained by a knowledge of the usual thickness of the beds of black slate clay† which cover it, the greater part of which are visible at the surface, immediately above the gulph, forming the steep acclivity of Culkagh mountain.

On leaving its source, the River Shannon at once assumes the deep, dead, and sluggish character, which it preserves for its whole extent. The elevation of the source of the Shannon, above Lough Allen, as ascertained by barometrical observations, is 115 feet, and above the sea is 275 feet.

The other tributary rivers are the Owenmore and the Arigna. The relative situation of these rivers will be seen by reference to the map.

The rocks, which form the coal series in the Connaught coal district, are similar to those usually met with in other coal districts. Besides coal, they consist of alternations of sandstone, sandstone slate, slate clay, clay ironstone, and fine clay.†

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† The average thickness of the beds of black slate clay is 600 feet.

The strata are arranged with great regularity, and dip or incline conformably with the limestone on which they rest, and contrary to the declivity of the hill. This is the case in the interior as well as the exterior sides of the hills; but the continuity of the different beds is frequently broken by the strata of one part of a hill having fallen or slipt down to a lower level from that of the other. These slips frequently occasion a difference of the level in the same bed, of twenty, forty, and even a hundred yards. A knowledge of the precise direction and amount of the fall of these slips is of the utmost importance to the coal miner; for if his workings, however excellent and perfect in their plan, be commenced and proceeded on in ignorance of these irregularities, when discovered in the progress of the work, they must lead to a greatly increased expence, or possibly to the abandonment of the colliery. With this view, great pains have been taken in prosecution of the survey, to ascertain the line of direction of the principal slips of the district. They will be found marked on the map in their proper situations.

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† A particular description of the distinguishing character of these several rocks will be found in the Introduction to the Report on the Leinster coal district.

OF THE STRATIFICATION OF THE CONNAUGHT COAL DISTRICT.

The general arrangement and alternations of the strata are extremely simple, and comparatively few in number; but they are not exactly similar in all parts of the district, though some of them may be traced throughout.

OF THE SOUTHERN AND WESTERN DIVISIONS OF THE CONNAUGHT COAL DISTRICT.

It has already been mentioned, that the deep vallies of the tributary streams, which flow into Lough Allen, divide the district into four parts. The stratification of the southern and western divisions, situated in the counties of Roscommon, Sligo, and Leitrim, are nearly similar, and may be classed together. These divisions are the most important in the district, both in respect to the extent and quality of the coal, and the facility of communication with the river Shannon and the neighbouring country.

The southern division is bounded on the north by the valley of the river Arigna, and on the south by the limestone country, which forms the southern boundary of the district. It consists of one great mountain ridge called Brahlieve. Its length from the Arigna works in the county of Roscommon to the hills above Ballintogher in the county of Sligo is nine miles; and its average breadth from the edge of the limestone country to the river Arigna rarely exceeds two miles. This ridge of mountains is straight, steep on both sides, and flat at the top. The strata, both on the northern and southern declivities, dip contrary to their inclination, at an angle of from five to six degrees from the horizon, and form a flat curve in the centre.

The western division consists of the Mounterkenny mountains, which are bounded on the north by the Dorobally river, which falls into Lough Allen below Drumkeern; on the south by the river Arigna, which separates it from the southern division; on the east by Lough Allen; and on the west by the limestone country, which extends from Belhavel by Killenunnery to Ballintogher.

Though the strata are nearly similar in the southern and western divisions, it is not to be supposed that they are exactly the same in all parts; for a trifling difference will be found even in the short distance of twenty yards. Thus a bed, which is composed of soft slate clay, will gradually pass into sandstone slate, or thin beds of sandstone slate will be found interstratified with a bed of slate clay in one place, which do not occur in another. Beds of sandstone slate will also sometimes graduate into sandstone. But these are trifling variations, and of no importance to the miner: his guide should be the great and leading beds which occur in the country, whose general character and appearance are not materially affected by slight alterations either in the thickness or composition of some of its component parts.

The following table of the different rocks will shew the order, in which they occur in these divisions of the district, commencing with the limestone which lies below the coal series, and ascending regularly; ending with the bed of sandstone flag, which forms the uppermost stratum of the country.

TABLE OF STRATA.

		Thickness in feet.			
No.		Ft.	In.	Ft.	In.
1	Limestone, thickness unknown.				
2	Black slate clay. This bed rests upon the uppermost bed of limestone. Beds of sandstone slate, and even thin beds of sandstone are found interstratified with it towards the upper part. It contains numerous beds of clay ironstone, from half an inch to two feet in thickness. On an average its thickness is - -			600	0
3	Greyish white sandstone, known by the name of				

No.		Ft.	In.		Ft.	In.
	the first or great sandstone, from -	30		to	60	
4	Black slate clay -	9		to	20	
5	Grey sandstone -	6		to	10	
6	Sandstone with impressions, known by the name of seat rock	1		to	3	
7	Fire clay, called coal seat - -	1		to	3	
8	Coal, intermixed with thin laminæ of slate clay - -	1		to	3	
9	Greyish white sandstone	4		to	20	
10	Black slate clay -	6		to	15	
11	Sandstone - -	12		to	15	
12	Good Coal - -	2	6	to	3	4
13	Grey soft slate clay, coal roof - -	10		to	15	
14	White sandstone -	24		to	45	
15	Coal, upper bed -		8	to		9
16	Slate clay, in beds of various thickness, and different degrees of hardness, but generally soft and black. These beds contain innumerable thin beds of clay ironstone -	100		to	200	
17	Blackish grey sandstone slate in thin layers	30		to	60	
18	Sandstone flag -	30		to	50	

DETAILED DESCRIPTION OF THE DIFFERENT BEDS OF ROCK, WHICH OCCUR IN THE SOUTHERN AND WESTERN DIVISIONS OF THE CONNAUGHT COAL DISTRICT.

No. 2. Black slate clay.—The thickness of this great bed, or rather accumulation of beds, varies from three to six hundred feet, but in the southern division it rarely exceeds five hundred feet. It rests immediately on the limestone. This bed is remarkable from the number and richness of the beds of clay ironstone it contains. The most important occur at the height of from two to three hundred feet above the limestone. Whilst the manufacture of iron continued at Arigna, some of these beds were worked, particularly those at Altagowlan, on the banks of the river Arigna. There are many other valuable beds of clay ironstone contained in this black slate clay, besides the above. The number visible in ascending the bed of the Arigna, is scarcely credible. In many places the whole breadth of the bed of the river is formed of one flag of ironstone, which is many perches in length.*

The thin beds in most cases are the best; though that at Altagowlan, which is one foot thick, is amongst the richest I have ever met with.

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* During the continuance of the iron works, the peasants collected the ironstone, when separated from the beds by recent floods, and made good wages by delivering it at the works, at the rate of two pence per hundred weight.

Beds of sandstone slate, and thin beds of sandstone, are sometimes found interstratified with the upper bed of this great mass of slate clay.

No. 3. GREYISH AND SOMETIMES YELLOWISH WHITE SANDSTONE. Next in importance to the coal and clay ironstone, we may place this accumulation of sandstone. It consists of a series of beds of various thickness and fineness of grain. The thin beds are much esteemed as flags; and the thick as building stone in different parts of the country. But for want of roads very few quarries are accessible for horses; and but one, with great danger, for cars.* On this account these most valuable quarries are comparatively of little use.

From its superior hardness this sandstone has remained unchanged, while the action of the weather has mouldered away, for a considerable depth, the softer beds of slate clay, which lie immediately above and below it, and left the sandstone projecting.

After much enquiry and minute examination of several precipitous ravines, in different parts of the district, in which the whole of the black slate clay beds were exposed to view, from the limestone up to the great sandstone, it was satisfactorily ascertained, that no bed of coal, or any substance of value, excepting the clay ironstone already mentioned,.occurs in the district beneath the great sandstone; and consequently it becomes a guide of the utmost importance to the mineral surveyor, and serves as a point, or general station to be reached, previous to the commencement of any new mineral researches.

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* The only passable road is that to the quarry above Castle Tenison.

It sometimes happens, particularly in the north eastern division of the district, that this great sandstone forms the upper stratum of a tract of mountain; of course no particular investigation was requisite in such situations.

Though this sandstone varies considerably in thickness in different parts of the district, still it always retains the peculiar appearance of a projecting perpendicular crag or cliff, situated near the summit of the mountain, but elevated in some places one thousand feet more than at others. This is occasioned either by the increased thickness of the beds of black slate clay, No. 2; or by an unusual elevation of the limestone strata, which lie beneath the whole. Culkagh mountain, which will afterwards be described, affords a striking example of this fact.

No. 4. The great sandstone is succeeded by a bed of black slate clay, which contains nothing of importance.

No. 5. A BED OF SANDSTONE, which is rarely less than six feet thick, but frequently exceeds ten feet; it is in general more compact and harder than the great sandstone, No. 3.

No. 6. Sandstone two feet thick, containing impressions of vegetable substances. This species of rock is universally known in the Irish collieries by the name of seat rock. This name is derived from its position with respect to a bed of coal. It is usually succeeded by fire clay, which is succeeded by a bed of coal. It sometimes happens that the fireclay is wanting, and then the coal rests on the seat rock.

No. 7. Fire clay, called coal seat. In some parts of the district this bed is three feet thick; in others it is found two feet, and one foot; but in most places it is but a few inches, or is altogether wanting. These thicknesses are given from observations made in tracing the bed at its *outgoing*, or where it appeared at the surface. But it is probable that, were it of sufficient value to defray the expence of following it into the hill, the bed of fire clay would be found in most places to be three feet thick. In the valley of the Arigna, half a mile above the iron works, this bed was found to be three feet thick, and of excellent quality; and the whole of the fire bricks used at the works were made from it.

OF THE FIRST BED OF COAL.

No. 8. The fire clay is succeeded by a bed of coal, which varies in thickness from one to three feet. It is known in the country by the name of the crow coal. It contains numerous thin laminæ of black slate clay, which render it of little value, except for burning lime. When first brought to the surface it is moderately solid; but on exposure to the air it soon divides into thin flakes.

This bed has never been wrought. If it were, I have little doubt its average thickness would be found to amount to three feet; but it has never been seen, excepting at the outgoing. In the vale of the Arigna, near the iron works, where the fire clay was wrought, this coal was three feet thick. This bed runs parallel to the three foot coal, which lies above it; and its outgoing may be traced along the face of the hills, through the greater part of the southern and western divisions of the district.

No. 9 and 10. The first of sandstone, and the other of slate clay, contain nothing worth mentioning.

No. 11. The lower part of this bed is composed of yellowish white compact sandstone: the upper contains numerous vegetable impressions. It is the seat rock of the second bed of coal. This sandstone bed is extremely hard, and usually projects from the face of the hill in the form of a great step, similar to that of the great sandstone bed No. 3 already described. This sandstone served as a guide to trace the line of the outgoing of the three foot coal, which lies immediately above it. In some places a thin bed of fire clay is found interposed between this seat rock and the three foot coal.

OF THE THREE FOOT COAL, NO. 12.

The future prosperity of the Connaught coal district may be said to depend entirely upon the produce of this bed, which, though of moderate thickness, is fortunately of great extent. Its quality, as fuel for domestic purposes, is excellent; and if used for smelting iron, it is amongst the best in the empire. According to the analysis of Kirwan, 100 grains are composed of 71.42 carbon.

23.37 mixture of asphast and maltha.

5.21 grey ashes.

Specific gravity 1.351.

This bed of coal was first discovered in the western division of this district, on the property of Mr. Jones, two miles to the west of Lough Allen, and close to the boundary of the counties of Leitrim and Roscommon. This colliery was considered of such importance, that a parliamentary grant was voted to aid the formation of roads to it, but nothing in consequence was effected, and the colliery was soon after abandoned.

Unfortunately the first discovery of the coal was made very close to one of the greatest slips, or faults * as they are commonly called, in the whole district, and the workings were commenced on the lower side. In the progress of working, whenever the colliers wrought upwards to the face of the slip, the coal was found to end; and no steps were apparently taken to ascertain whether or not it might be met with in other places.

The thickness of this coal is rarely less than three feet, or more than three feet four inches.

The line of its outgoing is dotted on the map. It follows the upper surface of the bed, No. 12.—Commencing at the iron works, it may be traced without difficulty along the northern face of the Brahlieve mountain, without any material interruption for four miles and a half, by Aughabehy colliery, nearly to Geeva point, in the county of Sligo, and from thence back again on the opposite side of the hill, to Tullylions' colliery; and afterwards round the eastern end of the mountain to the point above the Arigna works.

In the western division of the district the extent of coal is not so great as in the southern. Its boundary is also marked on the map, but not with equal accuracy, as the whole surface of the mountain is covered by bog; and the rocks, except at intervals, are completely concealed. This division may contain about 1200 acres of the three foot coal, which, added to 2800 acres

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* See Appendix, No. 5. Note.

contained in the southern division, make a general total of about 5000 acres in both divisions.

From this calculation we should deduct one-fifth part to allow for impurities in the coal, and the loss occasioned by slips and undulations. This, at the rate of 7840 tons per acre, will leave upwards of thirty millions of tons of coal as the probable quantity which may be raised out of the southern and western divisions of the district. It is difficult to calculate, with even moderate precision, what quantity of the coal may hereafter be consumed in the country; but if we take it at 50,000 tons annually, which is much more than it will probably amount to, and allow 10,000 tons for the iron works, with one blast furnace, the total annual consumption would be 60,000 tons. But the southern and western divisions contain upwards of thirty millions of tons of coal, which is sufficient to supply the supposed demand for 500 years.

OF THE DISLOCATIONS OCCASIONED BY SLIPS DOWN OF THE STRATA, IN THE SOUTHERN AND WESTERN DIVISIONS OF THE DISTRICT.

Excepting in those situations where very great slips down of the strata have taken place, these disturbances are rarely visible at the surface; they are usually discovered in the progress of working the coal.

The coal field of Aughabehy colliery is traversed by two great slips, which converge towards each other, as represented on the map. The eastern slip has thrown down the coal to the west, and the western to the east; between them the coal lies at a much greater depth from the surface than on their exterior sides. The coal field situated to the north of the river Arigna is also traversed by two principal slips, which run nearly at right angles to each other. They have divided the coal into three distinct parts. These coal fields are probably traversed by many other slips, which are not visible at the surface, but certainly by none of equal importance with the above.

OF THE DIFFERENT PLACES WHERE COAL HAS BEEN WORKED, IN THE SOUTHERN AND WESTERN DIVISIONS OF THE CONNAUGHT COAL DISTRICT.

It has already been mentioned, that the three foot bed of coal was first discovered on Mr. Jones's property, in the county of Leitrim. In this place a few acres of coal were wrought out, between the great eastern downthrow of the western division of the district, and the outgoing of the coal. (See map.) This colliery was known by the name of the Mounterkenny colliery. Adjoining to it on the opposite side of the stream, which forms the boundary of the counties of Leitrim and Roscommon, a few pits were sunk in the lands of Celtenaruny, belonging to Colonel Tenison, and Tullynaha, belonging to Mr. Lloyd; but very little coal was ever raised.

If we except two or three trial pits, which were made two miles to the south-west of the Mounterkenny colliery, it is the only place where coal has been wrought in the western division of the district.

The great extent of coal situated near the summit of the Table mountain of Mounterkenny, as represented on the map, remains unknown to the proprietors of the land, and the inhabitants of the country.

On an average, the Mounterkenny coal field is elevated seven or eight hundred feet above the level of Lough Allen. The surface of the mountain is covered with bog throughout, and no rock is visible, excepting on the declivity of the mountain. From this circumstance it is impossible, merely from external observation, to say at what depth below the surface the coal may occur in the interior of the field. A few trials, either by boring or sinking, in well selected situations, would satisfactorily determine this point. These trials are absolutely necessary as a preliminary to any extensive workings in this part of the district.

The extent and value of the great coal field in the southern division of the district is better known than that of any other in the country. In this division coal has been discovered and worked in many places near the outgoing of the coal, but particularly at Aughabehy and Tullylions on the property of Colonel Tenison; at the Rover colliery, near the iron works, on lands belonging to the Archbishop of Tuam; and at Greaghnagera, the property of Mr. M'Dermot. These collieries are all situated in the county of Roscommon.

OF AUGHABEHY COLLIERY.

During the continuance of the Arigna iron-works considerable workings were made at this place to supply them with fuel. The colliery is situated two miles to the west of the iron-works, and to the south of the great northern slip. The extent of the coal already wrought out does not exceed six or seven acres. Though this colliery was situated close to the declivity of the hill, the whole of the coal was drawn up to the surface through shafts; but the water was carried off by a level.

Aughabehy colliery was worked by the company, who carried on the iron works. It would appear from some of these works, which still remain, that this company meant at one time to work this colliery on a very extensive scale. They commenced driving a deep level from the

of the hill, and considerably
the coal, with an inten-
it entirely through
means unwatering
extends from the
of it; but this magnifi-
doned before the level or
en driven a sufficient length
e.

was commenced on too low a level,
pparent cause of its abandonment was
nous expense of sinking air shafts to ven-
e it. Had it been commenced fifty yards
elow the level of the outgoing of the coal, instead of the great depth at which it was attempted, no more than one air shaft would have been requisite till after it had been driven a considerable distance under the coal, and the second air shaft might have been commenced and sunk from the coal downwards to the drift.

At Aughabehy the coal inclines towards the south at an angle of 7° from the horizon, which is equal to a slope of one foot in ten, and consequently, for every ten yards the water drift had to proceed beyond the outgoing of the coal, the depth of the air shaft would diminish one yard. These air shafts, sunk underground from the floor of the coal to the water drift,*

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* The whole of the Duke of Bridgewater's collieries near Manchester are worked according to this plan.

would have the effect of ventilating both the water drift and the colliery; for, after the air shaft was perfected, a current of air might easily be carried, commencing at the mouth of the water drift, ascending the air shaft to the colliery, and afterwards passing through the different workings of the mine ascend any old coal pit that might be selected.

A large fire should be made at the bottom of the coal pit, to rarify the air, and by this means force the current in the direction desired.

If this water drift were carried on five hundred yards, it would reach the coal. But, long before it arrived there, it might render the most essential benefit to the mine, not only in conveying off the water, but by being used as a canal the whole of the coal might be cheaply and expeditiously drawn out in small boats. To reach the boat level it would be requisite to let down the coal through the air shafts, and the descending full buckets or baskets might draw up the empty ones. This plan would be much less expensive than drawing the coals through deep pits up to the surface.

By reference to the section of the rocks, as given in the table, it will appear that, fifty yards below the level of the coal, the strata are composed of soft slate clay; consequently the first two hundred yards of the boat level would pass through this rock, the next eighty yards through the great sandstone, which is composed of alternating beds of sandstone and sandstone flag, which may be easily wrought. The remaining one hundred and twenty yards would pass through the crow coal, and alternations of sandstone and slate clay.

The cutting through eighty yards of the great sandstone would be the only expensive part of the proposed boat level.

OF THE METHOD OF WORKING THE COAL AT AUGHABEHY COLLIERY.

The three foot coal at Aughabehy, and in most other places where it has been worked, is divided into three parts. Commencing from the bottom the sandstone seat rock is covered by one foot four inches of solid coal; this is succeeded by two inches of slaty coal called kelves, and over this again is one foot six inches of solid coal of excellent quality. The roof is composed of soft dark grey slate clay. The coal is easily separated from the roof; it rarely adheres strongly to it.

The plan, which was followed in working the colliery, was simple and well adapted to the nature and arrangement of the bed of coal. It was what is called the broadway. When the pit was sunk to the coal, double drifts * were carried on both sides of it forty yards in length

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* The method of driving double drifts, and supplying them with a constant current of fresh air, is described in page 81 of my Report on the Leinster Coal District.

on the level of the bed, that is at right angles to its dip. These drifts being parallel, of course one was more to the dip of the stratum, or on a lower level than the other. The workings were commenced from the upper side of the upper drift, or, as miners term it, the upper side of the rise drift.

Ten colliers, called clearers, were sent into the drift, who placed themselves four yards asunder, and commenced working by cutting out or clearing away the bottom of the coal, close to the floor. When these ten men had finished their work, they had made an incision in the bottom of the coal, three feet in from the face of the drift, and six inches high, for the whole length of the working, or forty yards.

The clearers were followed by two breakers and fillers, who broke down the coal by wedges driven in at the top, and afterwards fitted it into wooden boxes having slides fixed to the bottom. Each box held two hundred weight. Four hurriers were next employed to draw the coal from the working to the pit bottom, from whence it was drawn up the pit to the surface. This being completed, a pillar-man was sent down, who built small pillars to support the roof, with sandstone, which had previously been let down the pit for that purpose. These pillars were placed in the centre of the drift, at the distance of three feet from each other.

The next day the whole operation was repeated, and a second row of stone pillars were built, one yard to the rise of the first, and three feet asunder.

As the work proceeded, a passage, called a hurrying road, was formed diagonally from the pit, so as to reach the farthest angle of a rectangular working, which varied according to circumstances from sixty to eighty yards in length, but rarely exceeded forty yards in breadth. To preserve this hurrying road, walls were built on both sides, formed of the roof of slate, which was taken down to encrease the height of the passage.

To preserve a constant current of fresh air at the workings, air courses were formed between walls built of the slate of the roof on both sides of the breadth of the general working, and communicating with the lower drift first made.

When the workings were carried on to a length of seventy or eighty yards from the pit, double doors* were placed in the hurrying roads, to force the air round the circuit of the air courses.†

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* The advantage of using double doors in the workings of a colliery is explained in page 83 of my Report on the Leinster coal district.

† A plan and description of the broad method of working coal, very similar to that here described, is given in my Report on the Leinster coal district. The principal difference consists in stone permanent pillars being substituted for move-

The principal objection to this plan of working is, that the air courses are composed of porous walls built of slate clay, instead of being cut, as is usual, out of the solid coal, and protected on either side by pillars of coal. But at Aughabehy colliery, as formerly worked, the pits were so shallow and numerous, that little precaution was requisite to supply the moderate extent of the workings of each with fresh air.

Had the colliery been more extended, and the workings been carried further to the dip, a more perfect system of ventilation would have been indispensable; for, in proportion to the increased depth of the coal from the surface, fewer pits would have been sunk, and a greater extent of workings must necessarily have been ventilated from each.

The number of pits formerly worked at Aughabehy colliery caused a great encrease per ton in the expense; as each pit required a certain establishment, and consequent expense, whether little or much coal was raised out of it.

From the best calculation I have been able to make, a ton of coal of twenty hundred weight cost the Arigna company, when delivered on the pit bank, about four shillings, exclu-

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able wooden ones; and the hurrying road being made diagonally across the coal working, instead of through the permanent air courses.

sive of the royalty to Colonel Tenison of one shilling per ton. Had horses been used under ground to draw the coal to the pit bottom, and the works in each pit more extended, it might have been raised for three shillings per ton, and even less, if the boat level system were brought to perfection.

In the last working of this colliery a contract was made with the Arigna company by Mr. John Colthard,* to supply them with coal at the rate of five shillings per ton at the pit mouth. There is at present but one pit at work at Aughabehy. It is situated to the south of the old colliery; and Colonel Tenison, the proprietor, pays five shillings a ton to the colliers for delivering it to him on the surface. The quantity of coal at present raised per week, on an average, is about twenty tons.

TULLY LIONS' COLLIERY.

This colliery, which belongs to Colonel Tenison, is situated to the south of Aughabehy, and on the opposite side of Brahlieve mountain. It has been partially worked at different times, and many pits have been sunk to the coal. Colonel Tenison is at present driving a short level, which will unwater a small extent of the coal, situated between the declivity of the mountain and the great western downthrow.

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* Mr. Colthard is still resident in the country, and I am much indebted to him for the information and the kind assistance he afforded me in the progress of my mineral survey.

When this level is completed, he intends to abandon the Aughabehy colliery and work at this place. His inducement to make this change is not from any variation in the quality of the coal, but to take advantage of the new road now making to Tully Lions.

Some pits have been sunk, and a small quantity of coal has been raised at a place called Greaghnagara, half a mile to the north-west of Tully Lions' colliery; and also near to the iron-works, at a place called the Rover. The coal raised at the latter colliery was inferior in thickness and quality to that of Aughabehy and Tully Lions.

This difference probably arises from the workings having been made close to the outgoing of the coal. When followed to the dip, there is little doubt of its being found equal to any in the country.

The Rover colliery is worked occasionally in the spring and summer. It may produce on an average 300 tons in the year. Aughabehy colliery produces about 1000. It therefore appears that 1300 tons per annum are the entire produce of the collieries of the southern and western divisions of the Connaught coal district, which contain, as already stated, upwards of 30,000,000 of tons of coal; the whole of which is at a moderate depth beneath the surface, and may be easily wrought.

But there are no passable roads to the coal hills, and until they are formed nothing can be effected. The lines of new road, which are apparently the most important, as leading to the principal markets, will be described towards the conclusion of this Report.

SECTION OF THE STRATA, CONTINUED.

No. 14. The three foot coal is covered by a bed of grey slate clay, which varies from ten to fifteen feet in thickness.

No. 15. It is succeeded by a bed of hard white sandstone, which forms the floor of the upper bed of coal. This sandstone varies very much in thickness. At Tully Lions' colliery it is twenty-four feet. At Aughabehy, to the north of the great slip, it is forty-five feet. At the Rover colliery a bed of slate clay, of fifteen feet in thickness, separates this sandstone into two distinct beds.

No. 16. Coal, which varies from eight to nine inches in thickness. It is the uppermost bed of coal in the district, and has not been met with, excepting in the southern division.

No. 17. The eight inch bed of coal is covered by an accumulation of beds, usually of black slate clay, containing numerous thin beds of clay ironstone, and sometimes beds of sandstone slate. This mass of slate clay is usually much decomposed at the surface; and sometimes it forms mural precipices near the summits of the hills. It varies from one hundred to two hundred feet in thickness.

No. 18. Blackish grey sandstone slate. This bed is easily separable into thin layers or flakes, and, though subject to decomposition, it is much used for roofing houses in the vicinity of coal districts. It is, however, much harder, and more durable in some quarries than in others. Its thickness varies from thirty to forty feet.

No. 19. Sandstone flag. This is the uppermost bed in the Connaught coal district. It is only to be met with in the summit of the Brahlieve ridge of mountain near its south-eastern extremity. This bed is also used for roofing houses, and is much superior to the foregoing for that purpose. It varies from thirty to sixty feet in thickness.

I have thus described the nature and thickness of the several beds of coal and other rocks, which occur in the southern and western divisions of the Connaught coal district, from the limestone upwards. It appears that these divisions contain but three beds of coal, only one of which is worth working. Yet this single bed, though but three feet in thickness, is, from its great superficial extent, sufficient to supply the country with fuel for many centuries.

OF THE NORTHERN DIVISION OF THE CONNAUGHT COAL DISTRICT.

This division contains the mountains of Lacka, Lugnacuilla, Culkagh, Doon, and Glanfarn or Mullaghurk, and several others of minor importance. It is bounded on the north, east, and west, by the limestone country, which forms the boundary of the coal district, and which on the map is coloured blue; and on the south by the valley of the Drumkeeran river, which separates it from the western division of the district, and by the deep valley of the river Owenmore, which separates it from the Slieve or Nirin mountains.

The surface of this division is much more diversified than those already described. The five mountains, already mentioned, do not form a single chain or group, but are separated from each other by deep and broad vallies, which also contain innumerable low but steep hills. The mountains are all of similar character. They rise at a steep angle from their bases, and frequently present mural precipices, from sixty to one hundred feet in height. On the summits they are all nearly flat, and covered with bog.

The general arrangement of the stratification is very similar to that of the southern and western divisions, though some diversity is apparent in the upper beds where the coal is found.

There is also some difference in the lower stratum, which, particularly in the valley between Lough Macnean and Lough Allen, is composed of sandstone.

In several parts of this valley limestone rises up from beneath this sandstone, and is quarried by the inhabitants, who burn it for manure. These risings up of the limestone are evidently occasioned by undulations in the stratification; for the beds are universally found to incline from the body of the limestone towards the adjoining sandstone hill, which covers it. These insulated tracts of limestone generally occur near the boundary of the coal district, but there are instances of their occurrence considerably in the interior: there is one three miles east of Dorobally, close to the river Shannon, upwards of three miles to the south of the nearest limestone boundary.

The situation of these small, but useful patches of limestone is shewn on the map by the blue spots within the boundary of the coal district.

The bed of sandstone, which covers the limestone, is very variable in its thickness. In some places it exceeds forty feet; in others it is less than ten feet. It is generally extremely compact, and difficult to break. Its texture varies from fine to very coarse grained. It is succeeded by a great bed, or accumulation of beds of black slate clay, from two to five hundred feet in thickness, similar to that already described as occurring in the southern and western divisions of the district.

Thin beds of a black and impure argillaceous limestone, very similar to calp, are found interstratified with the lower beds of the slate clay. Extensive quarries of this limestone or calp have been opened at the base of Glanfarn or Mullaghurk mountain near the road, which leads from Manorhamilton to Enniskillen; particularly at Cornacloy, three miles and a half from Manorhamilton. Several quarries have also been opened near Drumkeern and Dowbally.

The black slate clay is succeeded by a great bed of sandstone, which varies in thickness from forty to sixty feet. Some parts of this bed are extremely fine-grained, and of a yellowish white colour. Extensive quarries are worked in it near the summit of Glanfarn mountain, and the stones are drawn all over the country, and used for window-stools, flags, and sometimes for pillars and ornamental stone work. But the quantity raised is limited by the difficulty of conveying the stone from the quarries to the base of the mountain. At present there is no road, and all is drawn down the hill on rude slide cars. No pains are taken to open the quarries, and most of them at present are nearly filled up with rubbish.

Besides Glanfarn, this great bed of sandstone occurs near the summits of the mountains Culkagh, Lacka, Lugnacuilla and Corkagh; and

OF LACKA MOUNTAIN.

The base of Lacka mountain, on its west side, in the vale of Glanboy, is composed of limestone, which dips towards the mountain at an angle of 60°. It is covered by the great bed of slate clay. In this place the first bed of sandstone, already mentioned as occurring in the northern division of the district, is wanting. The slate clay is 615 feet thick. It dips in a direction contrary to the declivity of the mountain, at an angle of 6°. from the horizon. It is covered by the great sandstone, which in this place varies from sixty to eighty feet in thickness.

On the north side of the mountain the stratification has been much disturbed by three or four great slips; and the falling down of the sandstone stratum at each has formed a succession of abrupt precipices, with considerable flat intervals between, giving the appearance of gigantic steps. The perpendicular face of each cliff is formed of sandstone.

At first sight, the north face of the mountain appears to contain five successive beds of sandstone, each sixty feet thick. There is, however, but one bed of that thickness, which, by successive slips, has assumed the appearance first described; and this is fully proved by the occurrence of but one thick bed of sandstone in the vale of Glanboy, on the west side of the mountain; which bed, in continuation, forms the uppermost of the five apparent beds, visible on the north side.

These facts are the more dwelt upon, as the knowledge of them may prevent future mistakes, and possibly fruitless trials for coal.

The great sandstone on Lacka mountain is succeeded by a bed of slate clay, about thirty feet thick; and this by a second bed of sandstone, of about twenty feet. Above it is a series of layers of coal, which alternate with thin beds of sandstone; the layers of coal vary from four to six inches in thickness; the sandstone beds are each two feet thick. They contain irregular masses of coal. These alternating beds are covered by a stratum of sandstone slate, one feet six inches thick; it is succeeded by a bed of sandstone ten feet thick.*

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* An imperfect trial for coal has been made by some peasants on the summit of Lacka mountain. The openings were made like quarries. The strata sunk through were,

	Ft.	In.
Sandstone flag	10	0
Alternating thin layers of soft micaceous sandstone slate, and coal	1	6
Slaty coal, called kelve . . .	0	3
Sandstone, containing coal and vegetable impressions	1	10
Coal	0	5
Sandstone, containing coal and vegetable impressions	1	8
Coal	0	6

Sandstone not penetrated.

This bed was traced round the summit of the mountain, forming an irregular ellipse, whose area may contain about two hundred and fifty acres.

The appearance of this coal, and the layers of rock which accompany it, are not very similar to any of those contained in the southern and western divisions of the district. In point of situation, it occupies the place of the first bed of coal, known by the name of the crow coal, but in other respects it bears no resemblance to it.

Nearer to the centre of the summit of the mountain, the sandstone, which covers the coal, is succeeded by two distinct beds of sandstone of considerable thickness. The intermediate space is so covered by bog, that the beds of slate clay, or other substances which are probably interstratified with them, are not visible at the surface.

The last bed of sandstone forms the uppermost stratum of the mountain. It is extremely irregular in its appearance. In some places it is much shivered and broken. If the coal already discovered at Lacka mountain be the first, or crow coal of the southern and western divisions of the district, we may expect to find the three foot coal beneath the uppermost sandstone and resting upon the second; but unfortunately its occurrence there is very doubtful.

The coal of Lacka mountain is but three miles distant from Manorhamilton, and ten from Sligo. At present there is no road to it, and, owing to the great elevation* of the coal above Manorhamilton, much skill will be required to select the most eligible line.

LUGNACUILLA.

If we except the interposition of a bed of sandstone at the base of this mountain, between the limestone and the black slate clay, its stratification is similar to that of Lacka, at least as far as the great sandstone.

This rock, which is full sixty feet thick, forms a mural precipice near the summit of the mountain. It is succeeded by a bed of black and grey slate clay, which varies from twenty to thirty feet in thickness. Above it is a bed of sandstone three feet thick. This bed forms the floor or seat of a bed of impure slaty coal, ten feet thick. Towards the centre of the stratum there is a layer of good coal, which varies from six to ten inches in thickness. Above the coal is a bed of soft black slate clay, twenty feet thick. It is succeeded by a bed of hard coarse-grained sandstone, fourteen feet thick: this

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* According to barometrical measurement, the coal in Lacka mountain is 1150 feet above Manorhamilton.

bed reaches the boggy surface of the mountain. Towards the summit there are two additional beds of sandstone; but the strata, which lie between them, are so concealed by a deep covering of bog, that it is impossible to ascertain their composition without sinking or boring through them.

The ten feet bed of coal is visible on the eastern face of the mountain at a place called Meneask, in the county of Cavan, where some trifling workings have been made. A pit was also sunk in the top of the mountain, a short distance from the face of the cliff. The coal found was similar to that visible in the precipice. Three other pits were sunk in search of coal in this mountain, but all of them were commenced beyond the outgoing of the coal, and sunk through strata which lie below it. Two were commenced in the slate clay, which rests upon the great sandstone, and one in the great mass of slate clay, which lies below that rock.

The situations of these pits must have been selected by persons unacquainted with the general stratification of the country.*

The extent of the impure bed of coal in the summit of Lugnacuilla mountain may be about 600 acres. Part of it lies in the county of Cavan, and part in the county of Leitrim. The boundary of these counties crosses over the summit of the mountain.

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* I understand they were made by order of Mr. Pleydel, the proprietor of the land, by some English colliers who were brought over for the purpose.

It is possible that the bed of sandstone, already mentioned, which lies twenty feet above the ten feet coal, may be the floor or seat of an upper stratum, though none of the vegetable impressions, and other characteristic marks which usually distinguish a seat rock, were visible in it. But the uppermost layer may not have been seen, which is frequently the only one that contains those impressions.

According to barometrical measurement, the coal pit at Meneask is 1010 feet above Lough Allen, and 1170 feet above the level of the sea. There is at present no road to it.

OF THE EASTERN DIVISION OF THE CONNAUGHT COAL DISTRICT.

This division is bounded on the north by the valley of the river Owenmore, which separates it from the northern division; on the west by Lough Allen; and on the east and south by the limestone country which bounds the coal district.

It is composed of one mountain group, known by the name of Slieve a nirin.* The external appearance of these mountains is similar to those contained in the southern, western, and northern division of the district; but in some respects the stratification is different.

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* The Iron Mountain.

In many places the limestone, which forms the substratum of the coal district, is succeeded by an alternation of thin beds of sandstone, slate clay, and sometimes grey impure limestone; these strata, in the aggregate, amount to upwards of one hundred feet in thickness. They occur in the line of country between Drumshambo and Aughacashiel.

To the north-east of Aughacashiel these strata are succeeded by a bed of white sandstone, which varies from ten to forty feet in thickness. This sandstone is covered by the great bed of black slate clay, which occurs in every part of the district. It varies in thickness from three to five hundred feet. The slate clay is succeeded by a bed of sandstone forty feet thick.

In some places thin beds of slate clay are found interposed between the sandstone beds at Aughacashiel. The section of the strata, from the great sandstone upwards to the summit of the mountain, is as follows:

	Feet.	*In.*
The sandstone is covered by grey sandstone slate - -	60	0
Sandstone - - -	5	0
Coal - - - -	1	6

	Feet.	In.
Fireclay, extremely slaty and impure, from 8 feet to - -	10	0
Sandstone - - -	2	0
Coal, irregular and slaty - -	1	6
Sandstone, extremely irregular, and varying in thickness from 6 to	30	0
Sandstone containing vegetable impressions - - -	3	0
Coal, slaty and impure, varying in thickness from 6 inches to -	1	0
Black slate clay - - -	15	0
Greyish white sandstone -	80	0
Black slate clay, visible in the face of the precipice, - -	50	0

This stratum reaches the flat surface of the mountain, but, as the strata incline towards its centre, it may be of great thickness. Nothing further can, however, be discovered without sinking through the deep bog, which extends over the whole table surface of the top of the mountain.

It would appear from the foregoing section, that the eastern division of the district contains three beds of coal. Their superficial extent is very great; but they are extremely irregular, and the strata, which accompany them, were never found to be the same for a quarter of a mile in any direction.

Finding this to be case, less trouble was taken to ascertain the actual extent of the coal

OF THE IRON WORKS.

The number and richness of the beds of clay ironstone, that occur in all parts of the Connaught coal district, appear at a very early period to have attracted the attention of Irish speculators; and works on a very small scale, called Bloomeries, were carried on in various parts of the adjoining country, as long as any wood remained to supply them with charcoal. At that time no coal had been discovered, and if it had, the process of making iron from pit coal was then, though partially known, not practised even in England.

The iron works of Drumshambo were the last that continued to work: they were given up about the year 1765. These works were situated at the southern extremity of Lough Allen, in the county of Leitrim, a quarter of a mile west of the village of Drumshambo.

The works were built upon a limestone rock, but about a quarter of a mile from the commencement of the coal country. The situation was particularly favourable for making iron at a cheap rate. The ironstone was chiefly collected from the eastern shore of Lough Allen, and in the beds of the precipitous streams which descend from the Slieve a nirin mountains to the lake.

The appearance of trivial workings, made in search of the ironstone, are still visible along the borders of these streams. The ironstone, when collected, was conveyed by boats to the works; and charcoal from the vast woods, which at one time flourished in all the vallies, was carried by the same means. Limestone, the only remaining ingredient for smelting iron, was quarried close to the works.

Judging from the accounts given by the oldest inhabitants, and the remains still visible, the Drumshambo iron works appear to have consisted of one blast furnace, three feet square* in the interior, and about eighteen or twenty feet high.

Large heaps of ironstone, of excellent quality, still remain at the works. It is much superior to the greater part of that used at the more modern Arigna iron works. The smelted iron from the Drumshambo works was carried to the neighbouring village, where it was forged into bars.

OF THE ARIGNA IRON WORKS.

These works were commenced in the year 1788, by three brothers of the name of

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* The whole of the ancient iron works, that I have seen in Ireland, were of similar construction.

O'Reilly. At that time the practicability of smelting iron with charred pit coal, or coak, instead of wood charcoal, was well known, and long practised in England and Scotland with great advantage to the adventurers.*

The Arigna works, being the only ones ever erected in Ireland to smelt iron with pit coal, attracted great attention, and their want of success has in consequence been deeply felt. It is of some importance, that the true cause of their failure should be investigated, that men of capital and enterprize may not be deterred by groundless fears from embarking in a speculation, which, if conducted with judgment and prudence, would enrich themselves, and be of infinite advantage to the country.

From a very minute examination made on the spot, the quality of all the requisite materials were found excellent in their kind; and although the cost of each, when delivered at the works, was greater than it might have been ones were injudiciously destroyed. Amongst the latter was the removal of the iron rail-way from the inclined plane to the north of the furnace pool. It was a very useful work, though not perfect, as there was a rise from the bottom of it to the works, which might easily be avoided; the construction of the great dam across the Arigna, above the works, was inconsiderately undertaken, as the destruction of the bank on either side was a catastrophe, which might naturally have been expected from the constant pressure of an immense body of water, aided, in time of flood, by the furious rapidity of a precipitous mountain torrent.

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* A patent was granted to Dudley for making iron with pit coal in the year 1619; but his works were destroyed by the populace, instigated, it is supposed, by the iron masters who made iron from charcoal. No further attempts appear to have been made for upwards of a century. Between the years 1750 and 1760, many blast furnaces were erected in England and Wales to smelt iron with pit coal, and the number continued afterwards to increase rapidly. In the year 1788, the year in which the Arigna works were commenced, there were fifty-three blast furnaces in England and Wales, and six in Scotland, whose annual produce in cast iron amounted to 53,800 tons.

It would be useless to enter into any more minute detail respecting the cause of the failure of these works; but I have great confidence in asserting, that there is no situation in the empire, in which cast iron can be manufactured at a cheaper rate, or of superior quality, than at Arigna.

The Arigna works are situated at the southern base of Brahlieve mountain, on the west side of the river Arigna, and about one mile distant from Lough Allen. The works, as first constructed, were divided into two distinct parts, the upper and lower works. The iron was smelted, and all castings were made in the upper works; and the lower were confined to rendering cast iron malleable, and forming it into bars, &c.

The upper works; at present consist of,

A large furnace pool;

A blast-furnace, forty-four feet high, and twelve feet in the bosh;

One large overshot water-wheel, twenty-six feet in diameter:

It worked two cast iron cylinder bellows, which blew the furnace, and also a large boring mill attached to the water-wheel shaft:

One double steam engine of Bolton and Watt's construction, the cylinder thirty-two inches in diameter, with a blowing cylinder five feet four inches diameter. This engine was used to blow the furnace in dry seasons, when there was not a sufficiency of water to work the water-wheel.

One foundery, with a cupola furnace.

One horse-mill for grinding fireclay.

Three draw-kilns for roasting the ironstone, with store-houses, offices, and other buildings.

The furnace-pool is large, and has been formed at a considerable expense; but the supply of water was uncertain, particularly in the summer season, which was of great detriment to the works.

To remedy this defect the steam engine was erected. It would have been better to have taken in part of the river Arigna, by forming a weir about a mile above the iron-works, and carrying a mill-race nearly on a level from thence to the works. The mill-race would certainly have been expensive, as there are many small mountain streams, over which it must have been carried by aqueducts; but the expense would soon have been repaid by the blast furnace being constantly kept at work, and by the power it would have given of working any machinery on the level of the lower works by the water from the tail-race of the furnace wheel of the upper.

The blast furnace is extremely well erected, and firmly bound together. The interior is lined with fire-brick, and is in good repair. Previous to the stopping of the work, the whole of the bottom was removed, apparently to make some improvements.

The large water-wheel is extremely strong, and well constructed: the arms are made of oak, and are well framed together. With some slight repairs to the buckets, the wheel might be set to work without delay. The blowing apparatus would require some repair, and a water pressure should be added to render the blast regular.

The double steam engine has been ill constructed from the beginning. The top of the blowing cylinder has been taken off, and the interior, from being exposed to the weather, is now quite eaten with rust. The air-pump is in a similar condition, and the steam cylinder and working gier are so much out of repair, that little benefit can ever be derived from the engine, without expending more money on it than it is worth. There is a new steam boiler in the yard, which has never yet been set; it is much corroded by long exposure to the open air. The cupola furnace is apparently in good order, as are also the draw kilns for roasting the iron-stone.

The roof of the store-houses and other buildings have lately been repaired; they contain a great variety of excellent patterns for casting.

Little need be said about the lower works; they are at present in such a ruinous state, that nothing but the stones, and some iron materials which remain, can ever be converted to any use.

According to Mr. John Grieve's Report,* they originally consisted of a forge with a refining hearth, worked by an overshot water-wheel of sixteen feet in diameter, with three cranks on its axis, working three cylinder bellows, each thirty inches in diameter; a mumbling hammer, about three tons weight, worked by an overshot waterwheel, thirteen feet in diameter and four feet eight inches broad, with air furnaces, &c. &c. for puddling. A slitting mill with two overshot water-wheels of twenty feet in diameter and four feet and a half broad. The rollers and cutters were each thirteen inches in diameter.

There are two houses for managers, in tole-

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* See Appendix, No. 1.

rable repair, belonging to the works, and some houses for workmen.

From what has been said it appears, that the only part of the Arigna works, which are immediately available for any useful purpose, consists of the upper works. If the mill-race already proposed were completed, a very moderate sum would be sufficient to fit the blast furnace for immediate work.

OF THE PRICES, AT WHICH THE DIFFERENT MATERIALS CAN BE DELIVERED AT THE WORKS.

The ingredients necessary for smelting iron consist of clay ironstone or iron ore, coal, limestone, and moulding sand.

In describing the stratification of the different divisions of the Connaught coal district, the probable quantities of the two principal ingredients, namely ironstone and coal, contained in each, have already been mentioned; but the means and price, at which these could be delivered at the works, remain still to be considered.

During the time that iron was made at Arigna the works were supplied with coal from Aughabehy colliery in the southern division of the district. The distance between the colliery and the works is two miles, and the outgoing of the coal is about five hundred feet above the furnace bank at Arigna. A road has been made with a tolerably regular descent from the colliery to the works.

Formerly the greater part of the coal was carried on horses' backs, and cost, according to Mr. Grieve's Report, for carriage, three shillings and four pence per ton of twenty hundred weight. Should the works be recommenced, a railway may be laid on this road, altered in some places so as to preserve a more regular descent. This would reduce the price of carriage, from the colliery to the works, to three pence or four pence per ton.

If the coal from the Rover colliery were found to be of equal quality with that from Aughabehy, a short connecting railway might be laid from it to join that already proposed.

The price formerly paid for raising the coal, including royalty and all contingencies, was five shillings a ton, which, with the price of carriage, amounted to eight shillings and four pence per ton at the furnace bank. During the last working a contract was made by a competent person* to deliver the coal at the works for seven shillings and six pence a ton.

If the general system of working and drawing out the coal, recommended in this Report, were adopted, and if railways were laid from the colliery to the works, there is little doubt

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* Mr. Colthard.

that coal might be delivered at the works under four shillings a ton.

The quality of the coal, as it relates to the making of iron, is excellent. According to the analysis of Mr. Kirwan, 100 parts of this coal are composed of

Carbon,	71.42	Specific gravity 1.351.
Bitumen,	23.37	
Grey ashes,	5.21	
	100.	

In coaking on a large scale, thirty-two hundred weight of the coal were found to yield twenty hundred weight of coak of excellent quality. The coak was made in the open air, by which some loss was sustained.*

OF THE IRONSTONE.

Numberless beds of clay ironstone occur throughout the Connaught coal district, interstratified with the great bed of slate clay already mentioned, which varies from three to five hundred feet in thickness. From the constant decomposition of this slate clay, immense quantities of the ironstone are annually detached from the beds, and are found in the channels of the different rivers and streams.

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* This is the general method practised at the English and Scotch iron works. Were large coaking ovens built, the expense of erecting them would soon be repaid by the saving in fuel.

Whilst the blast furnace continued to work at Arigna, it was almost entirely supplied with ironstone collected from the streams by the inhabitants, who delivered it at the works for three shillings and four pence per ton. But had it continued at work for any considerable length of time, this casual supply could not have been sufficient; and recourse must then have been had to the clay ironstone beds, which are in general thin and difficult to work. In this case the average expense of ironstone, when delivered at Arigna, would probably have increased to five or six shillings a ton.

Many very rich and moderately thick beds of clay ironstone are visible in the bed of the Arigna, particularly at the mill and at Altagowlan. At this place some trivial workings have already been made on two of the richest beds. Clay ironstone also abounds at the base of the Slieve a nirin mountains, on the east side of Lough Allen.

There is a great difference in the quality of the ironstone contained in the different beds; that at Altagowlan is among the richest.

OF THE LIMESTONE.

The Arigna iron works are very favourably circumstanced with respect to limestone, the third substance necessary for smelting iron. The nearest quarry is half a mile north of Keaduc, about one mile and a half distant from the works. The quality of the limestone is excellent. The present road from the quarry to the works is extremely ill laid out; it has been carried over a mountain of so steep an ascent that the whole of the limestone was necessarily carried from the quarry on horses' backs at the expense of four shillings per ton. If a proper road had been made in the valley at the base of the hills, it might easily have been raised and delivered at the works for two shillings a ton.

There is abundance of excellent moulding sand at Knockcranny, three miles distant from the works, and one mile beyond the limestone quarry. If the new road were made, it might be delivered at the works for two shillings and six pence per ton.

It thus appears that in the vicinity of Arigna ironworks there is abundance of coal, ironstone, and limestone, all of which can be delivered at the works at a moderate rate. We shall next consider the price, at which pig iron could have been made at Arigna by the first company, and contrast it with the probable expense for which it could now be made, were the proposed improvements carried into effect.

Expense of making a ton of pig iron, calculated from the cost of the different materials, when delivered at the works during the time of the first working:

	£.	s.	d.
Five tons of raw coal at 7*s*. 6*d*. per	1	7	6
Four tons of ironstone at 3*s*. 4*d*. per	0	13	4
One ton of limestone . . .	0	4	0
Expense of coaking, roasting, furnace-men, &c. &c. . .	0	10	0
	2	14	10
Contingencies at 20 per cent. .	0	10	7½
	3	5	5½

Expense at which a ton of pig iron could now be made, were the proposed improvements carried into effect:

	£.	s.	d.
Five tons of raw coal at 4*s*. per ton	1	0	0

	£	s.	d.
Brought over - - -	1	0	0
Four tons of clay ironstone[*] at 5s. per - - - -	1	0	0
One ton of limestone - -	0	2	0
Expense of coaking, roasting the ore, furnace-men, &c. &c. -	0	10	0
	2	12	0
Contingencies for timber, iron, wear and tear of furnace, machinery, &c. &c. at 20 per cent. -	0	10	5
Total expense[†] -	3	2	5

It would appear at first sight, from the foregoing statements, that there would be only an increased profit of three shillings per ton on pig iron, when the proposed improvements are finished, over and above the expense according to the first working. But this is not the case;

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[*] The expense, of a ton of ironstone in this estimate is calculated on the supposition that the works are to be supplied from beds of ironstone worked for the purpose, and not depending, as in the first working, on the ironstone collected from the streams.

[†] The expense, at which the different materials may be delivered at the works, is given from my own calculation. The quantities of coal, ironstone, and limestone, used in smelting one ton of pig iron, are ascertained partly from information collected from furnace men still resident at the works, and partly from the excellent Reports on the Arigna works by Messrs. Grieve and Guest. See Appendix, No. 1 and 2.

for the expense of raising ironstone for the new working is calculated at five shillings instead of three shillings and four pence per ton. Could ironstone be always afforded at the works at three shillings and four pence per ton, there would be a profit in the new works, above the old, of nine shillings and eight pence per ton; but unfortunately this cannot be expected, as all the loose ironstone would soon be collected from the streams, and then the only resource would be in working the beds.

These calculations are confined to the expense of manufacturing pig iron. Should the iron be re-melted, and cast into small articles, the diminution in the price of coal will greatly increase the profit; and if, as the works proceed, it were found advisable again to make bar iron,* the cheapness of coal will prove a great additional saving in the expense of the manufacture, and a proportionate increase of profit to the company.

OF THE DIFFERENT MARKETS FOR COAL AND IRON.

The situation, extent, and quality of the different beds of coal, contained in the Connaught coal district, have already been considered; as also the probable expense, at which coal might be raised and pig iron made at the Arigna iron works. Our next consideration will be how to dispose of these commodities at such a price, and in such quantities, as will fairly repay those who may hazard their properties in such speculations.

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* Those who wish for particular information, as to the probable expense of each stage in the manufacture of bar iron at Arigna, will find a very satisfactory estimate of it towards the conclusion of Mr. Guest's Report. See Appendix, No. 2.

The markets may be divided into two classes; those of the neighbourhood, which must be supplied by land carriage, and those at a distance, which are available by means of the river Shannon and the Grand and Royal canals.

The neighbouring markets consist of the towns of Sligo, Boyle, Cavan, and Belturbet, and the whole country between them and the coal district.

The bogs in the vicinity of Sligo are now nearly cut out, and that town is at present supplied with coal from Scotland, at an average rate of about forty shillings a ton.

It would appear from the custom-house books, that 5,000 tons of coal are annually imported into Sligo, the whole of which is consumed in the town and its immediate vicinity.

The town of Boyle is at present well supplied with turf; no immediate demand for coal in quantity can reasonably be expected there.

The towns of Cavan and Belturbet are situated in a country in the utmost distress for fuel. The small bogs, from which the inhabitants have hitherto been supplied, are now so nearly exhausted, that turf sells at an enormous price. The expense is so great, that many persons find it cheaper to draw English coal landed at Drogheda, a distance of thirty-five miles; and others, at the risk of destroying their horses and carts from the badness of the roads, have lately sent for coal to Aughabehy colliery in the southern division of the district. This is the only colliery at present at work, and, as has already been stated, not more than twenty tons per week are raised from it.

The English coal, when delivered at Cavan, costs three pounds per ton, that is, twenty-five shillings per ton at the ship, and thirty-five shillings a ton for carriage.

If coal could be laid down at Cavan for thirty-five shillings per ton, the county of Cavan would consume at least fifteen thousand tons a year.

The DISTANT MARKETS for coal consist of the numerous towns and immense extent of country on the banks of the river Shannon, and on the Grand and Royal canals. The Shannon market ends at Limerick, and that of the canals at Dublin.

It must not be supposed, that either of these cities will be wholly supplied with coal from the Connaught district. The freight of coal from Whitehaven to Dublin will, at all times, be less than from our own collieries by means of the navigation of the Shannon and canals. But in the event of a long continuance of adverse winds, the arrival of our own coal will tend to lessen the price both in Dublin and Limerick, particularly in the latter.

OF THE PRESENT STATE, AND REQUISITE IMPROVEMENTS IN THE NAVIGATIONS.

From what has been said it would appear that the country contains ample markets to consume our coal, if it can be delivered at a moderate price; but at present this is impossible. There are no passable roads to any of the collieries, and the navigation of the Shannon has been completed no farther than the entrance to Lough Ree.

The Directors General of inland navigation in Ireland are at present most actively employed in completing the Royal canal, to the river Shannon at Tarmonbarry; and it is generally understood that, as soon as it is finished, they will proceed to improve the navigation of the Shannon between Tarmonbarry and Lough Allen; and by this means encourage the recommencement of the Arigna iron works, and the working of the collieries.*

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* Since this Report was written the canal has been completed, and a grant of £15,000 was made the last session of Parliament for completing the navigation of the Shan- above Battle Bridge.

When the navigation shall have been completed, the iron rail way, already proposed to be laid from Aughabehy colliery to the iron works, may be continued down to the lake, from whence both coal and cast iron may be shipped for Dublin, Limerick, &c.

In calculating the expense of making a ton of pig iron, it has already been stated, that coal can be delivered at the iron works for four shillings a ton. The encreased expense of drawing it on the rail way, from the iron works to Lough Allen, will be very trifling. But to cover the expense of wear and tear of horses, waggons, railways, &c. we may calculate that the coal company, without any profit to themselves, could ship the coal at Lough Allen for four shillings and four-pence a ton. If to this we add the sum of three shillings and eightpence per ton, as an allowance for profit, and to cover contingencies, it would appear that coal could be sold at Lough Allen for eight shillings a ton. To this let us add the freight to Dublin by the Shannon and canal, a length of about 85 miles, at three-pence per ton per mile, that is, one penny per ton per mile toll, and two-pence per ton per mile freight to the boat owner; coal could, therefore, be sold in Dublin at the rate of £1 5s. 6d. per ton. The distance between Lough Allen and Limerick, by the course of the Shannon, is about 83 miles, and consequently, at the rate of two-pence half-penny per ton per mile, the cost of coal at Limerick would be under one guinea per ton.

But the navigation of the Shannon, particularly in Lough Ree and Lough Derg, is less certain than that by the canal where the boats are drawn by horses, and not subject to be delayed by contrary winds. This evil might be remedied by using steam boats on the lakes, (or perhaps for the whole length of the Shannon,) to draw* on the boats loaded with coal. Three coal boats might be drawn at a time by one steam boat, two tied in length, the stem of one to the stern of the other, and a third placed on one side, and fastened to both in such a manner, that its centre should be exactly opposite the joining of the two placed lengthwise. One steersman in the middle boat might steer the three.†

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* Steam carriages are now much in use, particularly in the north of England, for drawing coals on railways. In this case the steam carriage is separate from the coal waggons, which are drawn after it in a long line, usually consisting of from fifteen to twenty.

A steam engine, of the power of from four to six horses, might be placed in a boat of such a size, that its breadth, together with that of the propelling wheels on the outside, should not exceed twelve feet. There would be no difficulty in passing this boat through the different locks and bridges on the navigation of the Shannon.

† On the Duke of Bridgewater's canal coal boats are drawn united in this manner, between Worsley mill and Manchester.

OF THE ROADS.

The whole of the coal, which occurs in the Connaught coal district, is found in very elevated situations, when compared with the general level of the country. For this reason much skill is requisite in selecting the most eligible lines of road from the collieries to the neighbouring great towns.

The coal in the southern and western divisions of the coal district is by much the best and most valuable in the country: we shall therefore direct our principal attention to easy communications between these divisions and the neighbouring country. At present there is no direct road, at least none deserving that name, from either of these divisions to any town in the country. The town of Sligo, in a straight line, is but 14 miles distant from Aughabehy colliery, and the present road, round by the ironworks, is 22 miles in length. The best mode of communication between the collieries and the town of Sligo will be to make a new road from Aughabehy colliery, running under Geeva point, and from thence descending gradually through the parish of Killenunnery to the head of Lough Gill, half a mile below the village of Drumahair. A branch from this road can be made from Geeva to the Mounterkenny collieries. The whole length of the proposed road between Aughaliery and the head of Lough Gill could not much exceed nine miles. When finished, coals might be drawn on it in carts, and shipped at the head of the lake into large boats for Sligo, a distance of about seven miles and a half. By this means coals could be sold at Sligo for seventeeen shillings a ton; that is, seven shillings and six-pence a ton at the colliery, five shillings a ton land carriage to Lough Gill, two shillings and six-pence a ton freight and unloading at Sligo, and two shillings a ton allowance for loss of carriage, expense of storage, and profit to the coal merchant.

But even suppose a greater price than seven shillings and sixpence a ton were extorted at the colliery, still, with every allowance, excellent Irish coal could be sold in Sligo at twenty shillings a ton.

At present, as already observed, the inhabitants pay, on an average, thirty-five shillings, and frequently two guineas a ton for English coal. A line of canal was many years since laid out* to connect Lough Allen with Lough Gill, by following the valley of the river Bonnet; but, on account of the number of locks, the expense of this navigation would be very considerable.

To communicate with the counties of Roscommon, south of Leitrim, and Cavan, the coal should be drawn down the railway already mentioned, to a depôt near Lough Allen, from whence, by slight improvements in the existing lines of road, particularly at the extremities nearest to Lough Allen, easy communications could be opened with the adjoining country.

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* The survey and levels were taken by Mr. Larkin.

Coal, as already stated, could be sold at the depôt at eight shillings a ton; and, calculating the expense of land carriage at the rate of eleven-pence per ton per mile, the price it would cost the consumer may easily be ascertained. According to this scale the price of coals at Cavan, which is 23 miles distant from the proposed depôt, would be twenty-nine or thirty shillings per ton.

To connect the coal field of the western division with the depôt, either a new line of road or a railway will be requisite.

APPENDIX.

No. I.

Report of the Arigna Iron Works, &c. May, 1800.

THESE works are situated in the county of Roscommon, on the west side of Lough Allen, and within a mile of it; they are on the west side of the river Arigna, and at the south end of the mountain called Brahlieve, which abounds with iron-stone, coal, and lime-stone. There are other mountains in that neighbourhood, which also abound in these minerals, viz. the Cockra mountain, between the river Arigna and Lough Allen; the Iron mountain on the east side of Lough Allen, and the Dobally mountains at the head or north end of that lough.

In former times numbers of Bloomeries have been erected on each of those mountains, and these Bloomeries were continued till all the wood in the country was worked up; the last of them was at Drumshambo, at the south end of Lough Allen, and some people are yet alive who remember to have seen it at work. These Bloomeries were worked entirely with charcoal; for it was not at that time known, that iron, either cast or malleable, could be produced by means of pit coal: they worked upon no other mine but the iron stone from the mountains. The quarry of iron ore at Drummond, on the river Shannon, twelve miles below where this river issues out [illegible] [illegible], does not seem to have been then known, or, if it was, they had not found it to improve the quality of their iron, and they could not want it for any other purpose; such was their abundance of iron stone.

Some seven years ago, after it had been ascertained that cast and malleable iron could be produced by means of pit coal, the present iron works at Angus were erected immediately on the west side of that river, at a place where there had been a slitting mill for some of the old Bloomeries.

These works are on an extensive scale, and well executed; they are divided into upper and lower works.

THE UPPER WORKS ARE,

I. A blast furnace, forty-four feet high, and twelve feet wide at the bosh. The furnace bank descends to the bridge-house and tunnel head; so that the materials are thrown into the furnace out of wheel-barrows. An overshot wheel of twenty-seven feet diameter blows this furnace, and also works.
II. A very good boring mill.
III. A foundery with two cupolas, and room for a third cupola; with a complete set of patterns, potting-shops, and warehouses.

There is also at these upper works a horse mill for grinding fire clay by a stone on edge.

THE LOWER WORKS ARE,

IV. A forge with a refining hearth, worked by an overshot water wheel, of sixteen feet diameter, with three cranks on its axis, working three cylinder bellows, each of thirty inches diameter; and with a mumbling hammer of about three tons weight, worked by an overshot water-wheel of thirteen feet diameter, and four feet eight inches broad; with air furnaces, &c. for puddling.

V. A slitting mill, with two overshot water-wheels of twenty feet diameter, and four and a half feet broad each, rollers and cutters, each thirteen inches diameter.

And there is at these lower works a mill for grinding sad irons, and another for grinding blacking for the moulders; and there are two excellent houses for managers, and many very good houses for workmen.

The lower works, till of late, were supplied only with the water, which came from the upper works, and this was merely a few of the droppings from the east side of the Brahlieve mountain; but lately a dam has been made at a considerable expense across the Arigna, to wear this river into these lower works, and after this the lower works cannot be in want of water.

The droppings from Brahlieve were so far from supplying water to the blast furnace, that a double steam engine has been erected on Boulton and Watt's construction; its steam cylinder thirty two inches diameter, not cased; its blowing cylinder five feet four inches diameter, to assist the water-wheel in dry times. This fire engine has been erected at a great expense, and there was a great daily expense in maintaining it. It would have been much better, and still it will be proper to bring the Arigna into the furnace pool, that there may be always a sufficiency of water to blow the furnace, without having occasion to use the fire engine. On the furnace bank are three draw-kilns for calcining the iron stone; the surface of the water-lead may be taken on a level with the top of these calcining kilns; may be carried in the ground around the west side of the furnace pool, and then along the east side of the Brahlieve mountain, till it reach the Arigna, across which the dam to be made may be very inconsiderable. This level water-lead will serve the double purpose of conveying materials as well as water to the works. Hitherto the difficulty of conveying materials to the works has been excessive; the colliery is on the east side of Brahlieve, two miles distant from the works, and about eighty fathoms perpendicularly above them; and of the different methods they tried for bringing home the coals the preferable one was found to be on horses' backs. A horse carried three cwt. at a time; he went two rakes in winter, and three in summer, average two and a half loads of three cwt. seven and a half cwt. a day, forty-five cwt. a week. In this way the furnace would require sixty horses to supply it with coals alone, and reckoning each horse and its driver to earn only one shilling and three-pence a day, the collier's ton of thirty two cwt. would cost in leading five shillings and four-pence. Add to this, when the goods were made, they could not be got to the principal market, Dublin, under a land carriage of eighty-four miles, which in this country costs one shilling per ton per mile, and this amounted to a prohibition, particularly on pig iron.

Till these difficulties were removed, it would have been better not to have erected these works; and now that they were erected, it was reckoned expedient, about two years ago, to put a temporary stop to them. This stoppage need not be long—the Grand Canal Company are obliged, under a penalty, to join their canal to the Shannon by the end of 1803: their nearest junction is at Athlone, fifty-five miles from Dublin. From Athlone the navigation up the Shannon to Arigna is forty miles, thirty-four of which are already passable for small craft of ten tons, and it is now under the contemplation of Parliament to deepen this part, and to make the remaining six miles navigable. In all 95 miles.

And reckoning this, even at two-pence per ton per mile, the carriage from Arigna to Dublin will be under sixteen shillings a ton; and when the water-lead from the Arigna to the furnace-bank shall be finished, materials may also be carried on it for two-pence a ton per mile.

The coal which they were working on Brahlieve, two miles north from the furnace, was only twenty-seven inches thick at the outburst, where they began to it, but, having driven eighty yards to the dip of their deepest or water drawing pit, it gradually thickened, so that at the end of these eighty yards it is three feet thick, including one and an half inch of black slate. The coal dips into the hill one in twelve. On the other side of the mountain, and about a mile distant, Mr. Tennison is working the same seam of coal, dipping also into the mountain; it is therefore what is called a swilly or trough coal, and in the swilly the coal will be found to be very flat, and considerably thicker than it is elsewhere. The Brahlieve coal was wrought in the long way; the colliers were paid from four-pence to six-pence for holing a square yard; but latterly they were paid by the collier's ton, from one shilling and four-pence to one shilling and ten-pence.

A collier's ton is thirty-two heaped bushels; each bushel eighteen and a half inches diameter, and eight inches deep; weighs, when heaped, one cwt. of coals; a collier's ton is therefore thirty-two cwt. and say it

	s.	*d.*		*£.*	*s.*	*d.*
cost for holing . .				0	1	10
One man employed to break the coals at the wallfaces, at per day .	1	8				
One man for filling ditto . .	1	1				
For five tons . . .	2	9	per ton	0	0	6½
Two boys to draw these from wallfaces to barrow-road at eight-pence each	1	4		0	0	3¼
Two barrow-men to wheel them to bottom, at 1*s.* 1*d.* . .	2	2		0	0	5
One pit bottom boy . .	0	8				
One gin boy . . .	0	8				
One banksman . . .	1	1				
For ten collier's tons . .	2	5		0	0	3
Two gin horses belonging to the proprietor, suppose 3*s.* a day, each on ten tons, . . .				0	0	7
One man constantly employed in quarrying freestones for the buildings in the long way of working,	1	4				
One carter to lead these stones	0	10				
One cart horse . . .	3	0				
On twenty tons, or two pits work	5	2		0	0	3
Carried forward - - -				0	4	2

	s.	d.	£.	s.	d.
Amount brought over . .			0	4	2
One smith for sharping colliers' picks and shoeing horses, per week .	6	0			
One carpenter, three days a week, repairing barrows, slipes, gin, &c. at 1s. 6d. per day . . .	4	6			
On a 120 colliers' tons . .	10	6	0	0	1
There was an expense of drawing water, ten yards from the bottom of the pit to the upper level, two horses, one by night and one by day, per week . . .	22	0			
Two men at 1s. 1d. per day each .	1	2			
Two boys at 8d. per day each .	9	4			
On 120 tons . .	66	6	0	0	7
And there was 2s. 8½d. a yard for making in the barrow-road four and a half feet high—breast 20 yards on each side—40 yards, by 1 yard in—20 colliers' tons .			0	0	2
Upholding gins, gin ropes, slipes, and barrows, ...			0	0	3
Sinking pits and running levels . .			0	0	9
Expense of raising a collier's ton . .			0	6	0
Lordship paid to Mr. Tennison, the ground owner, 2s. per ton, but no lordship paid to him on iron stone or lime stone, and no ground damages paid to him—the lease from him perpetual			0	2	0
Carried forward - - -			0	8	0

	£.	s.	d.
Amount brought forward	0	8	0
Carriage of a collier's ton from the pits to the furnace-bank, as per 5th of this, . .	0	5	4
8*s*. 4*d*. per 20 cwt.	0	13	4

So the coals cost, laid on the furnace-bank, 13*s*. 4*d*. a collier's ton of 32 cwt. and this collier's ton, when coaked, yielded 20 cwt. of coaks. The seam yielded 2-3ds great coal and 1-3d small, but this small was also coaked, and, when kept free of slate, its coak did as well for the furnace as the coak of the great coal; but the expense of coaking it was greater, for in place of open hearths it had to be coaked in small ovens, each holding a collier's ton.

The quality of this coal is much like that of the coal at the iron-works in South Wales; it has little flame and little smoke, is ill to kindle, and burns to a white ash.

A level was begun to be carried into this colliery from the west side of the Arigna, and about 30 fathoms perpendicularly above it: this level is within 90 yards of the water drawing pit, and it will have 80 yards further to go to be at the wall-faces. It is, however, proper to drive in these 170 yards, and to continue it always before the workings. This level is 5 feet high and 4 feet wide: it was customary to take the deeds out of it in boats, and it will be proper also to boat the coals out by it. It is about 30 perpendicular fathoms below the present wall-faces; so, instead of ginning up the coals as formerly, they will be to let down these 30 fathoms by a roller and curb, which is a much easier and cheaper operation; but in order to render the level convenient for this purpose, it ought to be cut one and a half or two feet deeper; the additional expense of this is trifling, where the deeds are taken out by boats, and where the prevailing strata of the mountain are black thill. In this way the expense of bringing the coals to the furnace-bank will be lessened at least 5*s*. 6*d*. per collier's ton, viz.

	s.	d.	s.	d.
Gin horses and boy,			0	8
Drawing water,			0	7
The expense of leading the coals from the level mouth to the furnace will be 1*s.* 1*d.* per ton, viz. 2*d.* a ton per mile on the canal—2 miles ——4*d.* a ton of 20 cwt. per collier's ton,	0	6½		
There will be a descent from the level's mouth to the level water lead, of about 30 perpendicular fathoms, suppose it require as much to let the coals down this descent,	0	6½		
	1	1	1	3
There will in this case be a saving in leading of (page 86)			4	3
Saving per collier's ton,			5	6
And per ton of 20 cwt.			3	5
And the cost of delivering a ton of 20 cwt. on the furnace-bank will be (page 89)			4	11

The ironstone was wrought by the tenants and country people, and led by them to the furnace bank for 2½*d.* per cwt. of 120lb. in full of every expense, and they gave one to the score as usual. This amounts to 3*s.* 8*d.* for 20 cwt. of 112lb.

There will in future be a saving on the iron-stone, that will be boated along the water-lead to the calcining kiln-heads, in as much as it is cheaper to carry it in that way than on horses' backs.

The limestone was also carried on horses' backs, and laid down on the furnace bank for 2*s.* 6*d.* per 21 cwt. of 120lb. and this is equal to 2*s.* 3*d.* for 20 cwt. of 112lb.

The pig-iron, which was made at Arigna, was excellent for castings, and it ran into as fine goods as any pig-iron in England. To make the ton of 20 cwt. of it:

	£.	s.	d.
5½ tons of raw coals were required, the ton being 20 cwt. of 112lb. averd. these at 4*s.* 11*d.* a ton, as above mentioned, amount to	1	7	

	£.	s.	d.
Brought forward	1	7	0
4 of said tons of raw iron-stone were required, and these at 3s. 8d. is	0	14	3
23 cwt. of lime-stone was required, this at 2s. 3d. the said ton, is	0	2	7
Cost of a ton of pig-iron in materials,	2	4	3
The price paid in Shropshire to undertakers, who calcine the materials, work the furnace and the blowing fire engine, is 7s. a ton of 20 cwt. of pig-iron. This will be as cheaply performed at Arigna, where wages are lower, and where there will be only water machinery; but call it the same, 7s. English is	0	7	7
The ton of pig-iron will then cost at Arigna, *(Irish)*	2	11	10
or *(English)*	2	8	0
Which includes every expense except that of small coal for calcining iron-stone, for which purpose the broke of the great coal is generally taken; but put for this, and for upholding the tare and wear of the machinery,	0	12	0
Total cost of making a ton of pig-iron,	3	0	0

The iron produced at Arigna is so soft that, unless some of the Drummond ore were mixed with the iron-stone, there will probably be a great waste in converting the pig-iron into malleable iron. From what was done formerly it was said, that 35 cwt. of pig-iron was required for making 20 cwt. of rod-iron. Even if this waste cannot be lessened, by using a mixture of the Drummond ore, or by using peat earth, with which the country abounds, in some part of the refining process, still rod-iron could be made to great advantage; but until another blast-furnace be erected, for which the level water-lead will bring a sufficiency of blowing power, there is not likely, over what will be required for castings, to be much pig-iron to spare for the forge or slitting mill.

The average produce of the furnace at Arigna is estimated at one thousand tons of pig-iron yearly; and considering the ten shillings a ton duty on iron imported into Ireland, which duty is to be continued after the Union, a ton of pig-iron at Arigna may be valued at £8 sterling. This is a moderate price for pig-iron fit for castings; and as there is already on the spot machinery for converting the pig iron, that may not be fit for castings, into bar iron and nail rods, the whole of the one thousand tons a year may very well be rated at £8 a ton; and when we deduct the £3 cost of making a ton of pig iron, (page 91) there will remain £5000 a year profit of the Arigna works, when only the present furnace is employed; but on erecting another furnace the profit will be somewhat more than doubled, as working one furnace is attended with nearly the same fixed expense as working two.

The limestone and ironstone at Arigna are of the best quality, and inexhaustible. The coal is not yet discovered in such plenty; the thickest seam of it they have yet met with is only three feet, and this is on the Brahlieve mountain, on which the works are situated. Four square miles of this coal have been traced, and, as one square mile of it will supply a furnace about five hundred years, there cannot be said to be a scarcity.

But though no seam of coal has yet been discovered thicker than three feet on Brahlieve, or on the adjacent mountain, Cockra, to which the canal or water-lead will also reach, it is likely thicker seams may be discovered on them; for there has been discovered on the neigbouring mountains, at Dowbally, a seam said to be ten feet thick.

JOHN GRIEVE.

APPENDIX, No. II.

Report of the Arigna Iron Works, by Thomas Guest, October, 1804.

THESE works are situated in the county of Roscommon, on the west side of Lough Allen, and within about a mile of it; they are on the west side of the river Arigna, and at the south end of the mountain called Brahlieve, agreeable to the description I had been given thereof; on which mountain are several veins of ironstone already open at the distance of about a mile from the works; but the principal veins or strata which I saw were by the side of the river, and had been lately worked by the inhabitants; there are three strata of ironstone at a place called Altagowlan, on the east side of Arigna, that may be worked to advantage, being, as I was informed, on the same lordship; yet, as they lie at the distance of about two miles from the works, the expense of carriage will be greater in proportion. There are also other strata near the top or south end of the mountain (Brahlieve) above the works, and I doubt not but others may be found near the works. A very considerable quantity of ironstone may also be raised at the Iron mountain on the east side of Lough Allen, (from whence, it seems most probable, the charcoal furnace, which has been carried on near Drumshambo, must have been supplied) and from the distance, I estimate the expense of raising and carriage to Arigna will be about 7*s.* 6*d.* per ton. The ironstone has hitherto been raised and delivered at the furnace by the tenants, at 3*s.* 8*d.* per ton of 20 hundred weight of 112 pounds; but when an extra quantity comes to be wanted, and the consumption regular, a greater quantity of mine works must be opened, levels drove, and roads made, the iron-stone will cost nearly double the present price, say 6*s.* per ton, in a short period of time.

There is only one vein of coal yet found on this mountain, which has been tried to make iron with, and whether there is any other or not is yet uncertain; it has been raised at a place called Aughabehe, by means of pits without a level, some of which are now open, but are so full of water as to prevent them from being worked. A level has also been drove at a very considerable depth below the vein, the distance of about two hundred yards; this level, it is said, is within ninety yards of the water-drawing pit, but, from being injudiciously done, part of it is fallen in; it is at present full of water and rubbish, and it is doubtful whether it will ever be rendered serviceable, at least not for many years, as, if drove to the extent, it would be about seven hundred yards beyond the water pit: upon the whole, it will be necessary to drive a new level at a less depth below the vein, so as to strike the vein about eighty yards beyond the present working; which will gain sufficient breadth for the present, and by driving the same under the water-drawing pit, and boring from thence to the level the water may be let out of the present colliery, and the old works carried on farther: the expense of driving this new level, I estimate to be about 5 or 600*l.* and, by laying dram plates therein, the coal may be brought out without the expense of winding up pits. Not having seen any of this coal, I can say nothing with respect to its quality; but, as an indication of its goodness, I saw some good grey melting iron at the works, which was made therefrom. There are also two pits lately sunk upon the Brahlieve mountain, at a place called the Rover; the second pit was sunk upon a fault. The vein, when first discovered at the bottom of the pit, was not two feet thick, but, on drifting to the deep a few yards, it increased to two feet three and a half inches, which work at present yields very little water. This vein may probably turn out to be the same as that at Aughabehe, notwithstanding it at present deeps in a contrary direction.

It is adviseable to drive a level to this coal also, as itwould be highly imprudent to have a work dependant on one level; for, should any accident happen by a fall on the road, &c. the whole works may be put to a stand; when, if there were two or three levels, it may be supplied while the other is repairing, and the coal may be then brought out as described for the Aughabehe colliery. With respect to this coal, about two thirds of it may be coked in the open air: but, as the other part is quite small, it will be necessary to have a quantity of ovens to coke it in; and even then this small coal, being mixed with slate, will not be of so good a quality or so fit for the furnace as the other; which I understood was the case with Aughabehe coal. I have seee some of the Rover coal coked and used in the cupelo; it melted the iron very quick and well, which I consider is a symptom of its good quality; and, from what I could judge, have little reason to doubt its answering the purpose of making iron, especially that part of it which can be coked in the open air. The cost of raising this coal, and delivering it at the furnace-bank, I estimate at *6s. 4d*, per ton.

The limestone, being at the distance of two miles, has formerly been carried and delivered at the furnace at *2s. 3d.* per ton; the price of carriage of which may probably advance as the consumption becomes regular and the provender scarcer to keep horses in the winter. Sand lies at a still greater distance, costs at present *5s.* per ton, and will be subject to the like inconvenience to get it carried. Having stated the situation of the ironstone, coal, limestone, and sand, I have now to say, that the works consist of a blast furnace, forty-four feet high, twelve feet wide on the bosh: the furnace bank being nearly level with the bridge-house and tunnel-head, the materials have been thrown into the furnace out of wheel-barrows; upon which bank there are three kilns for calcining the ore previous to its being thrown into the furnace. The furnace has been blown by an over-shot water-wheel, twenty-six feet diameter, and two cast iron cylinders, seven feet diameter, worked by cams upon the pistons with poisebeams. To the other end of the shaft is fixed the boring-mill. The water hitherto used, being only the droppings from Brahlieve mountain, having been found insufficient, a double steam-engine has been erected on Bolton and Watt's construction, its steam cylinder thirty-two inches diameter, not cased, its blowing cylinder five feet four inches, to assist the water-wheel, but, having been injudiciously completed, is now quite out of repair, and, the beams being broke, it will require a new one before it can again be put to work; and I apprehend there must be a new air-pump and condenser, the present ones being too small in proportion to the size of the cylinder; and supposing the engine in complete repair, the expense of coal to work it, oil, hemp, grease, wear and tear, and labour, would be excessive. It will therefore be adviseable to cut a new level to bring the Arigna water into the furnace pool, which, by the best information I could get, will be more than sufficient to work two furnaces. The expense of doing this, I presume, will be about £1000. The water thus brought, by widening the sole of the water-wheel, and adding some cog-wheels and a fly thereto, I think may be so contrived with the present blowing cylinders, by putting piston-rods and casting tops to them; taking away the poise-beams, and working with a crank a double stroke, to blow a sufficient quantity of blast for two furnaces; in which case three more mine-kilns should be erected, and another furnace The building of the boring-mill may answer the purpose for part of the casthouse, and the boring-mill attached to some other part of the premises. There is also a foundery with two cupelos, potting-shops, and warehouses for casting small castings; and in the casthouse there is a crane and an air-furnace for the purpose of making large castings; these are tolerably well adapted for carrying on the casting business. There is also a horse-mill for grinding clay by the old method of stone on edge, and a kiln erected for burning brick. This kiln is much too small, and the drying-room must be altered into a stove, to make brick in all weathers.

THE LOWER WORKS

Are, a pond calculated to receive the water from the tail of the furnace-wheel, below which there is a forge where has been a refining hearth worked by an overshot wheel of sixteen feet diameter, with three cranks on its axis working three cylinder bellows, each thirty inches in diameter; where has also been a shingling hammer worked by an overshot wheel of thirteen feet diameter, four feet eight inches broad, and two air furnaces, the one having been used as a pudling-furnace, the other as an air-chaffery, the stacks of which only are remaining.

A slitting-mill, where has been two overshot water wheels of twenty two feet diameter. There is one pair of rolls and cutters; the cog-wheels being made of wood with wooden cogs, from the length of time since they have been worked, must be nearly decayed. The water-wheels are all down except one; and this one, from being exposed to the weather and not being used, can be little better, the shafts only appearing to be good. This forge is ill adapted to the present improved method of making bar iron; as such, very few if any of the shafts will come into use.

There are also some workmen's houses, and two houses for agents, the largest of which is too small for a man who has a family, there being only two small parlours, a kitchen, and three bed-rooms; the situation thereof is also extremely bad; being built upon a level with the coke-yard, it will be at times so annoyed by the smoke from the coke-hearths and works, that it will be hardly possible to live in it. I would therefore recommend a house for the manager of those works to be built on the flat meadow on the other side of the Arigna. The bridge over the river being repaired, he would then be very near the works; and, by putting the front of the house towards the works, he would have a view of what was going forward at all times.

I have now to take notice of the present buildings, machinery, clerks' and workmen's houses, &c. &c. (exclusive of the stock of ironstone, coal, and limestone and other articles, as tools, &c.) with the valuation thereof; which I set down at £20,000. The expense of making it a complete work, viz. cutting the water-course from the Arigna to the furnace-pool, altering the blowing machine, widening the sole of the wheel, and putting iron ladles on, making and fixing a large cog-wheel of iron on the shaft with two other iron shafts and cog-wheels to work a fly-wheel, timber for framing, cast iron for standards and riders, &c. iron for bolts, widening the present wheel-pit, and altering the fly wheel-pit, a crank with two cast iron lever beams to work the pistons, piston rods (turned), cast iron tops to the present cylinders, with air-boxes and pipes to carry the blast, with pins, bolts, &c. building three mine-kilns, a new furnace, bridgehouse, coke-ovens, driving levels to the collieries, opening coal and mine works, making roads, drilling blocks of stone to lay the rails upon, dram rails, drams with wrought iron axles and cast iron wheels to carry the coal and ironstone to the works; coke-barrows, wheel-barrows, and cast iron wheeling-plates, to wheel the rubbish from the mine works, colliers' and miners' tools, tools of all kinds for the founders, fillers, cokers, barrow-fillers, mine-burners, bridge-stockers, cinder-wheelers, &c. &c. with a stock of ironstone, coal, and limestone to begin, for the upper works:

AND FOR THE LOWER WORKS

Making fineries, pudling-furnaces, bloom-furnaces, new water wheels, cog-wheels and fly-wheels, beds, standards, spindles, nutts, coupling boxes, different sets of rolls for rolling iron, cast iron plates for the floors, a planishing forge, boring-mill and mill for turning rolls, with tools and implements for making bar iron, boiler plates, nail rods, or hoops, if the iron, on trial, be found to answer for such purposes, which, if a little more of the coldshort iron ore can be found, I think it may. These expenses, together with a new house for the manager, and an additional quantity of workmen's houses, will cost nearly £20,000 more.

I must be excused saying any thing respecting the consumption, demand, conveyance, or market; being a stranger thereto, of which you say there is plenty of demand, and the greater part, if not all, would be fetched from the works. This being premised, I have now to say that I have not the least doubt of the works turning out to a good account, as will appear by the following estimates; and to convince you of the reality thereof, I should have no objection to hold a share in the concern.

Estimate of making a ton of pig and bar iron at Arigna.

	£.	*s.*	*d.*	*£.*	*s.*	*d.*
5 tons of raw coal, at 6*s.* 4*d.* per ton,	1	11	8			
4 tons of ironstone, at 6*s.* per ton,	1	4	0			
1 ton of limestone, at 4*s.*	0	4	0			
Working the furnace, calcining, coking, &c.	0	10	0			
For timber and wrought iron work for drams, barrows, tools, nails, steel, oil, leather, brass, black-lead, grease, sand, clay, repairs, wear and tear of machinery, rent, agencies, and other incidental charges,	1	5	4			
Ton of pig iron,				4	15	0
24 cwt. of pig iron at 95*s.* to a ton of finer's metal.	5	14	0			
Refining,	0	3	6			
Cokes, castings, bar iron for tools, wear and tear, &c.	0	10	0			
Ton of finer's metal,				6	7	6

	£	s.	d.	£	s.	d.
24½ cwt. of finer's metal at 6*l.* 7*s.* 6*d.* per ton,	7	16	2			
Puddling,	0	12	0			
Coal, 2 tons, at 6*s.* 4*d.*	0	12	8			
Wheeling ashes, weighing charges, rolling, unloading coal, master puddler's wages, bricks, sand, clay, repairing offices, castings, weighing puddled bars, tools, incidental charges, and wear and tear	0	19	2			
Ton of puddled bars,	———			10	0	0
23½ cwt. of puddled bars, at £10 per ton,	11	15	0			
Piling and heating, 3*s.* 6*d.* rolling, 3*s.* 6*d.*	0	7	0			
Coal, 25 cwt. at 6*s.* 4*d.* per ton,	0	7	11			
Repairing furnaces, sand, brick, castings, streightening, weighing bars and other labour, wear and tear of machinery, grease, and incidental expenses,	0	18	1			
Ton of bar iron,				13	8	0

I have now to remark (having been told by one of the iron founders in Dublin) that the price of best foundery dark grey iron is now sold at the works in Scotland at 8*l.* 5*s.* per ton, ordinary 7*l.* 5*s.* and bright 6*l.* 5*s.* from whence the founderies in Dublin get supplied; and supposing the iron could not be sold at the works, I conceive the best method to get it to market would be to carry it to Sligo: the expense of taking it there, weighing and wharfage, would not exceed 15*s.* per ton. The guide I have for this is as follows: Prior to our having a canal made from Merthyr to Cardiff, we were in the habit of carrying our iron on horses' backs over the hills, being the distance of twenty-four miles, for 13*s.* per ton; and, if I am rightly informed, the distance from Arigna to Sligo is only eighteen miles; from whence I apprehend they may be conveyed to most ports in Ireland as cheap as they can from the works in Scotland. But for the certainty thereof I must leave those to judge, who are better acquainted with the situation of the place. Admitting this correct, and the two furnaces were to make sixty tons per week, for fifty-two weeks would be 3120 tons. The profits arising from the works, if the whole were sold in pigs, would be as follows:

Say one half was inferior iron, then there would be

		£	s.
1560 tons of best grey, at 8*l.* 5*s.* per ton, ...		12870	0
1560 do. of inferior, at the medium between the two sorts, 6*l.* 15*s.* per ton, ...		10530	0
		23400	0
Making 3120 tons, at 4*l.* 15*s.* per ton, . , .	£14820		
Carriage of the above to Sligo, at 15*s.* per	2340		
		17160	0
		6240	0
If there could be 4 tons per week sold in castings, you would have to add a profit of 5*l.* per ton on 208 tons of castings, .		1040	0
Which would make a yearly profit of		7280	0

If the iron were not to be sold in pigs, then you would have to say that 3120 tons of pig iron will produce 1806 tons of bar iron at the rate of 35 cwt. of pigs to make a ton of bars, agreeable to the before-mentioned estimates.

Then 1806 tons of bar iron sold at the works at 17*l.* 5*s.* (This is the price as reduced by Messrs. Blair and Co.) but at the towns on the road between Dublin and Arigna the smiths pay 24*l.* per ton, . . .	31153	10
Making 1806 tons of bars, at 13*l.* 8*s.* per ton, ...	24200	8
Brought over	6953	2

	£.	s.
Carried forward	6953	2
A part of this may be rolled into bolts and five-eighths squares; you will therefore have to add 2*l.* per more for the quantity of iron, which may be made of these sizes, say 70 tons at 40*s.*	140	0
	7093	2

If the iron will answer for hoops, I presume a large quantity may be sold. The present prices of these are 28*l.* per ton, and it was till lately sold at 38*l.* per ton by the ironmongers in Dublin. Say the rolling into hoops cost 5*l.* per ton more than bars; the difference between the price of making and the reduced price they are now for would be 9*l.* 12*s.* per ton.

(These calculations, as far as respect the manufacturing, are made according to the price of labour given in this country. Therefore so much as the price of labour can be reduced at Arigna, it will increase the profits.)

If the sudden fall of bars, which had taken place by Messrs. Blair and Co. should not be likely to continue, then the extra price, which it can be sold for, will be to be added to the calculations, viz.

Suppose bar iron to be sold at the works at 20*l.* per ton, the usual price it is sold at in Dublin, then the profit on 1806 tons at 6*l.* 12*s.* per ton will be -	11919	12

THOMAS GUEST,
Dawlais Iron Works,
Glanmorganshire.

March 1*st*, 1805.

APPENDIX, No. III.

GLOSSARY.

IT has frequently been objected to works of science, that the generality of readers are supposed to posssess a certain portion of knowledge, particularly of the first principles and technical terms, which are by much the most difficult to acquire, and of which, in most cases, they are perfectly ignorant.

As this work is intended to instruct persons unacquainted with the sciences of Mineralogy and Geology, technical terms have been avoided, as far as was consistent with clearness and brevity of description; still many have necessarily been inserted. To explain them the following Glossary has been formed, which it is hoped will prove useful and satisfactory to general readers.

ARCHITE.—A fossil bivalve shell, with equal valves; the name is derived from the peculiar form of the joint, which presents a hollow somewhat resembling the interior of a boat.

BEDS.—The rocks, that occur near the surface of the earth, are usually divided into parallel layers, which are easily separable from each other; the substance of each layer being perfectly distinct, and frequently composed of a different substance from those, which lie either above or below it; these layers are called beds. Thus a layer or bed of coal usually rests on a bed of fire clay, and is covered by a bed of sandstone or slate clay.

CHAMITE.—A fossil bivalve shell: it occurs petrified in great abundance in the great limestone district of Ireland.

CALCAREOUS SPAR—or spar of lime, is lime in a crystalline form; this substance is composed of nearly equal portions of pure limestone and carbonic acid.

CLAY SLATE—Is a simple rock of the primary class, usually of a greyish blue colour; it is easily divisible into thin flakes; with the finer varieties of it the roofs of our houses are covered.

COPPER PYRITES—is the metal of copper combined with sulphur; it usually exhibits a bright yellow colour, and strong metallic lustre.

CROP OR OUTGOING—is that part of a bed of coal or other substance, which appears at the surface.

CRYSTALLINE STRUCTURE.—When a rock is composed of an aggregation of crystals, either of the same or different mineral substances, it is said to have a crystalline structure.

DIP.—The beds or layers of rocks, that occur near the surface of the earth, are rarely found either in a true horizontal or vertical position. They usually incline more or less from the horizon. This inclination is called the dip. If the inclination be towards the north, it is called a north dip; if to the south, a south dip, &c.

FAULT.—Fault is a general term given by coal miners to any irregularity, that is observed in the strata.

Faults may be divided into two classes, slips, and undulations in the strata.

Slips are those disturbances, which have apparently taken place by the slipping or falling down of one part of the strata to a lower level, leaving the other in its original position. The quantity of the depression varies from a few inches to many hundred feet.

Undulation.—When the strata, from being perfectly regular, and dipping to the south or any other part of the compass, suddenly change their inclination and rise in an opposite direction, and again as suddenly descend, and continue in their first inclination, they are said to undulate.

FELD SPAR.—Feld spar is a simple mineral substance of a white or greyish white colour; its fracture is foliated in every direction, and it breaks into rhomboidal fragments. Feld spar is one of the essential components of granite.

FLOETZ—means flat or horizontal; this name has been given to the class called secondary rocks, from their being generally found in a flat or horizontal position.

The celebrated Professor Werner of Freyberg, and his pupils, have classed the rocks, which compose the surface of the earth, into three principal divisions, which have been named primitive transition, and secondary, or floetz. Primitive rocks are stratified vertically, or approaching to vertical; their average inclination may be about sixty degrees from the horizon. Their internal structure is for the most part crystalline, and they rarely, and until lately were never known to contain any mechanically formed deposits.

The stratification of transition rocks resembles that of the primitive, upon which they rest. They contain not only mechanically formed deposits, as solid fragments; but organic remains of marine shells are sometimes found in rocks belonging to this class.

Transition rocks are intermediate between primitive and secondary, and they partake of the characters of both. The name was given by Professor Werner, who supposes them to have been formed during the passage and transition from its chaotic to its habitable state; but from its theoretical origin this appellation has been much objected to.

Secondary, or floetz rocks, are for the most part stratified horizontally, and they rarely exceed an angle of 45 degrees from the horizon; they rest upon transition rocks, and, when this class is wanting, which frequently happens, they rest upon primitive rocks.

Secondary or floetz rocks are chiefly composed of mechanically formed deposits.

FIRST FLOETZ SANDSTONE.—This rock is considered the oldest, that is, the first deposite of the secondary or horizontally stratified class.

FIRST FLOETZ LIMESTONE—rests upon the first floetz sandstone; it is considered the first or oldest rock of the secondary limestone species.

GNEISS.—The second rock of the primary class; its component parts are similar to granite; the difference between them consists in the arrangement of the mica in a particular direction, which is not the case in granite.

GRANITE—is a rock composed of an aggregation of crystals of three simple minerals, quartz, feld-spar, and mica; it is one of the primary rocks, and, from its being generally found beneath all others, it is classed as the first of the primary rocks.

GRAYWACKE—is a rock composed of an aggregation of grains, or rounded fragments generally of quartz, cemented by a paste of clay slate; it is the principal member of the transition class of rocks. The name is derived from a German word signifying rubblestone.

HORNBLENDE ROCK—is a greenish or blackish green rock, composed of an aggregation of crystals of the mineral called hornblende.

HORNBLENDE SLATE—is similar in composition to hornblende rock, but the crystals are smaller; the structure is slaty.

HURRYING ROADS—are passages left in a colliery, through which coals are drawn to the bottom of the coal pit.

INFLAMMABLE COAL—is distinguished from carbonaceous or non-flaming coal by its blazing quality; it is composed of carbon or charcoal and bitumen.

IN SITU—in its native bed.

LYDIAN STONE—is a black, and sometimes greyish mineral, of the nature of flint; it is frequently found in rounded nodules, and sometimes in irregular beds, interstratified with the first floetz limestone. This substance is frequently called basanite and touchstone.

MADREPORE—is a petrifaction of the coralline species; it occurs in great abundance in limestone rocks.

MICA—is a simple mineral of the argillaceous genus; it exhibits a strong metallic lustre, and is easily separable into thin elastic plates. The name is derived from the Latin word *micare*, to shine.

MICA SLATE—is a stratified schistose rock of the primary class; it is composed of quartz and mica.

NON-FLAMING COAL—is a simple mineral substance, composed of from 90 to 96 per cent. of pure carbon or charcoal, and from 4 to 10 per cent. of ashes; it is distinguished from inflammable coal by its containing no bitumen; it burns without flame or smoke.

OUTGOING.—See Crop.

PRIMARY ROCKS.—See Floetz.

QUARTZ—is a simple mineral of the siliceous genus; it is found crystallized in the form of a six-sided prism, terminated by a six-sided pyramid at both ends, corresponding with the planes of the prism; but it is rare to find more than the prism and one pyramid perfect.

QUARTZ ROCK—is a rock of the primary class, composed of an aggregation of grains or imperfect crystals of quartz.

ROCK CRYSTAL—is a transparent variety of quartz. The composition and crystallization are similar.

SANDSTONE—is a rock composed of a granular aggregation of particles, or rounded fragments of quartz or siliceous sand, cemented by a calcareous, argillaceous, or ferruginous paste.

SANDSTONE SLATE—is a rock, which frequently occurs in the coal formation, interstratified with sandstone and slate clay; it partakes of the character of both those rocks.

SERPENTINE—is a simple rock of the magnesian genus and primary class. The name is derived from its varied hues, and the silky and serpentine appearance of the asbestos veins, by which it is frequently traversed.

SLATE CLAY—is a rock belonging to the secondary or floetz class; it occurs in great abundance in the coal formation; it is usually of a bluish black colour, which graduates into grey. By exposure to the atmosphere it quickly disintegrates, and becomes a tenacious clay.

SLIP.—See Fault.

STEATITE—is a simple mineral substance of the magnesian genus; it is easily distinguished by its soapy feel; when free from iron, this substance is of great value as an ingredient in the manufacture of porcelain.

STRATIFICATION.—See Beds.

SULPHUR PYRITES—is a simple mineral substance of a bright yellowish white colour, and strong metallic lustre; it is composed of sulphur and iron.

SULPHURET OF LEAD—or common galena, is a minera substance composed of lead combined with sulphur. Lead ore, as it occurs in mines, is usually found in this slate.

SYENITE—is a rock of the primary class, composed of feldspar and hornblende; the name is derived from the town of Siena, at the cataracts of the Nile, where this rock occurs in great abundance.

TRANSITION ROCKS.—See Floetz.

UNDULATION.—See Fault.

VEIN—among miners is the mineral repository, in which the ore of any metal is found; but veins are sometimes composed of rock, and contain no metallic substance.

FINIS.